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ABSTRACT

This document reviews the development of science education in 17 Asian countries since 1969. Also included are seven articles relating to special aspects of science education in Asian countries, and a bibliographical supplement. (SL)

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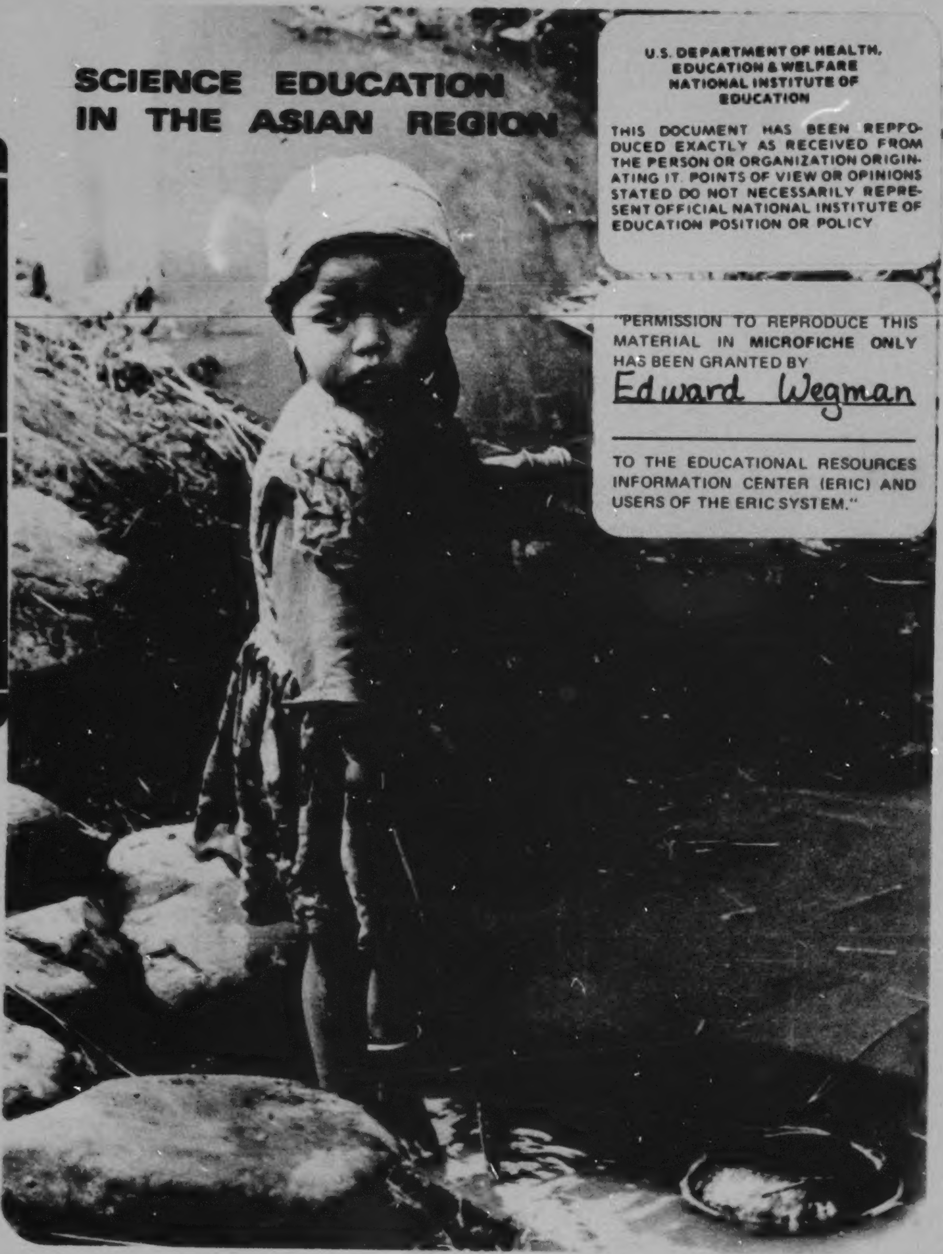
BULLETIN
# of the Unesco Regional Office for Education in Asia

Number 18 June 1977

SCIENCE EDUCATION IN THE ASIAN REGION



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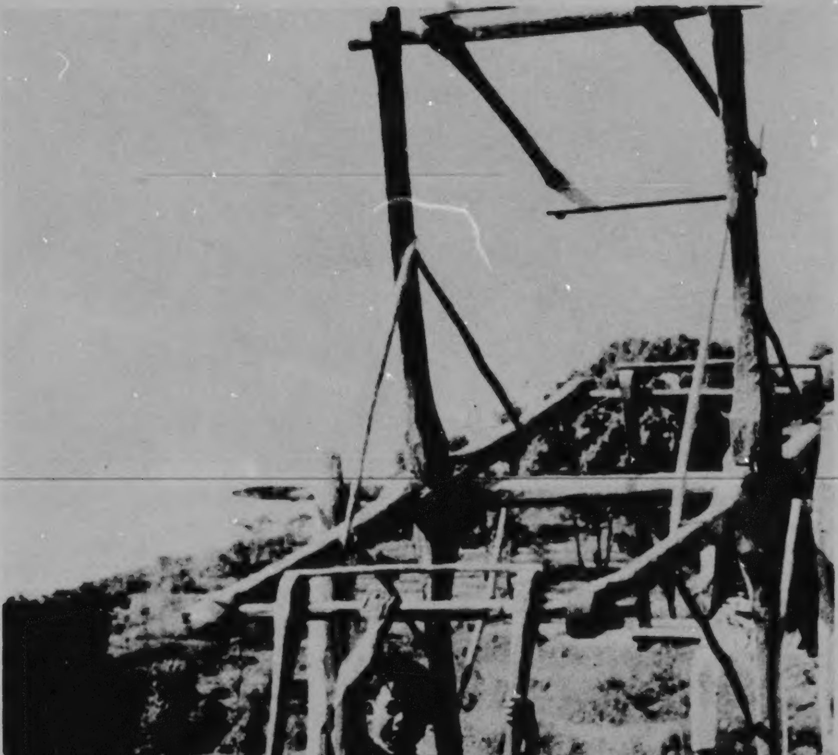

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SECTION ONE

REVIEW OF SCIENCE EDUCATION IN THE ASIAN REGION

Bulletin of the Unesco Regional Office
for Education in Asia
Number 18, June 1977

SCIENCE EDUCATION IN THE ASIAN REGION

Eight years ago, the *Bulletin* in its September 1969 issue, reviewed the position of science education in the countries of the Asian region. The reform of science education in the schools had emerged during the 1960s as an important concern, and a number of countries in the region had initiated a variety of new science programmes. The present issue of the *Bulletin* revisits the scene and brings together 17 country reports which were presented to a regional meeting convened by Unesco[1] and six articles specially prepared for this issue by science educators who are actively engaged in some of the major science education programmes in the Asian countries. A seventh article ("Where is education going? ") is reprinted from the journal *Physics Education.*

Science education continues to be a major concern in almost all the Member States, and high priority has been accorded to its expansion and qualitative improvement. Scarce resources have been committed in the belief that this investment would yield dividends in the national development programmes. Increasingly, recognition is gaining ground that special attention needs to be given to science not only as a school subject but also for its role in all spheres of everyday life, and that it must be an integral part of everyone's basic education.

In quantitative terms, the expansion of science education has been well ahead of the expansion rate of total enrolments. In all countries of the region, primary science in one form or another is one of the core subjects for compulsory study. (The situation in 1965, at the time of the Second Regional Conference of Ministers of Education in Bangkok, was that nearly 65 per cent of the primary pupils in Asia completed their first-cycle education without ever being exposed to learning experiences in science). Science is continued as a compulsory offering at the 'junior secondary' stage and its importance is enhanced by a strong trend discernible in a number of countries towards unifying what were earlier known as

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[1] *Trends and Problems in Science and Technology Education in Asia,* Report of a Regional Meeting, Singapore, 20–26 July 1976.

'primary' and 'junior secondary' (or 'middle') stages. At the second level, science subjects are offered generally as electives, and efforts are directed to increasing the number of seats in science courses. In countries where science subjects are part of compulsory study, the allocation of time for science has been significantly increased.

By far the most significant recent development in the developing countries of the region has taken the form of establishing a separate institution for curriculum development in science. Prior to the 1960s, the typical arrangement in almost all the developing countries in Asia was for science to be dealt with by a syllabus committee. More often than not, there were different committees–and sometimes even different organizations–to formulate the syllabuses for primary and secondary education. Generally, the institute now assumes the role of planning science education at these levels. In some countries, the institutes or centres are concerned only with science education while, in others, science education is a part of the comprehensive responsibility of the institute for curriculum development. This institutionalization of curriculum development work in science education has also led to the association of expertise from various bodies within and outside the educational system in developing new science curricula.

All countries in Asia, without exception, have chosen curriculum as the focal point of their programmes for the renovation of science education. This was in one way inevitable: a curriculum is a concrete expression of what goes on in education as a formally organized activity. It, however, also implied that the science education programmes had to be conceived within an existing structure of the education system and be limited by it.

The initial efforts in science curriculum development, until the late 1960s, tended in most countries to be the adoption or adaptation of science curricula designed in developed countries. A major shift is now discernible towards development of indigenous curriculum programmes based on experiences gained in earlier projects. This is reflected in the new instructional materials which incorporate more local experiences and use of the learners' environment, both natural and man-made, and locally available resources to provide first-hand science experiences, especially at the basic level. Increased freedom for teachers to design their own learning/teaching experiences based on a centrally developed curriculum or within certain general guidelines, to meet the individual and local needs of their students, is receiving more attention than the 'first generation' materials which were highly prescriptive.

Although a traditional approach to teaching science as a body of facts (knowledge) is still prevalent, there is now a discernible shift in all

new programmes from closely-directed learning of established facts to conceptual understanding through the application of acquired knowledge and skills to life problems. There is greater stress on first-hand experiences by pupils in the learning process with emphasis on enquiry and the discovery approach. Greater concern is also visible for the 'processes' of science. Similarly, instead of emphasizing the structure and logic of science disciplines, a shift is evident towards the application of science, and incorporating a knowledge of technology in the science programmes.

The stage in the education system for which the new science curricula were first developed differs from country to country. In some countries the secondary level was taken up first, apparently in the belief that improvement of secondary-level science would give immediate pay-off in improved science teaching at university level and also in the preparation of science teachers for the school system. In other countries the beginning was made at the junior secondary stage. In either case the extension to primary science was rather slow, and when it occurred, the curriculum development style of secondary level was all too obvious. In some countries the strategy of beginning at the top has been changed, almost wholesale, and the focus shifted to the basic cycle of education. By far the largest proportion of pupils are those who will terminate their formal schooling at the end of the basic cycle (whether it be 4–5 years or 8–9 years). The exposure to science learning experiences that they get in the basic cycle is all that they are likely to have when they enter the world of work and living. The central problems of curriculum in science education relating to 'relevance', objectives and methods are to be encountered in their most challenging forms when one has to deal with science education in the basic cycle or primary education in its own terms, rather than as a watered-down version of secondary school science.

Arising out of this, there is a strong tendency towards a unified or integrated approach to the content within the various branches of science at the basic cycle. In some Member States, attempts have also been made to integrate science with areas of social sciences and humanities and the real-life situation of the child as a major source of learning.

Although experimental try-out of new curricular materials, micro-testing and using formative evaluation to revise the materials before introducing a new science curriculum have been used in some countries, a systematic built-in curriculum evaluation has not yet emerged as an integral part of the curriculum development process.

The science curriculum programmes have been developed as a 'package' of instructional materials, textbooks and guides, and in-service training of teachers. The difficult problem of the 'material base' (equipment for the programmes) was not long in making itself felt as a constraint. In response, many countries in Asia have established centres for designing and developing equipment suited to local conditions and using local raw materials. When science education programmes encounter the compulsions of mass education, the problem of 'material base' will be magnified manifold. Clearly, innovative approaches are called for. In some countries thinking is moving towards evolving science education programmes, particularly at the basic level, which should be capable of providing valid learning experiences without being dependent on traditional equipment. The linking of science education with work experience, interlocking of cognitive knowledge and practical application, and the use of environmental and community resources, are obviously important elements in this approach.

Out-of-school science programmes in such forms as science clubs, science fairs, science centres and zoological parks have been started in many Member States, but a great many of them appear to cater to in-school population outside the regular school hours, rather than to young people who are not in school.

FISH CULTURE
TAWIS

More and more Member States of the region are moving in the direction of making their education system, at least at the basic level, available and relevant to the entire society. This new concept of basic functional education has emphasis on health and nutrition, development of employable skills and rural development. Science as an integral part of this education has its focus on preparing the learner to deal with real problems, in particular those brought about by the impact of technology on the physical, cultural and socio-economic environments.

In order to develop the science education component of the above programme, there has been a greater keenness to have regional co-operation in the sharing of experiences and for co-operative development of guidelines, approaches and materials, which is exemplified in the Asian Programme of Educational Innovation for Development.

Although science curriculum development activities have been undertaken with enthusiasm, the implementation has not been without shortfalls. There are a number of reasons for this, perhaps the most important being a fragmented rather than a systematic approach to changes in science curriculum due to:

a) The piecemeal nature of efforts which do not link curriculum development to national policy with the assurance of continuity of efforts and availability of support;

b) A lack of systematic efforts to co-ordinate changes in teacher education, material production, and instructional and management systems;

c) Insufficient mobilization of needed resources;

d) In the context of a centralized system of curriculum development, lack of communication and co-ordination at the level of schools and teachers.

While the Curriculum Development Centres have been used for the preparation of the textbooks and other related instructional materials and training programmes and thus closely involved in the implementation of the curriculum in some countries, in others the agencies responsible for developing the instructional materials needed for the implementation of the curriculum are different from those responsible for developing the curriculum. Similarly, the examination systems (and this applies particularly to terminal examinations at the second level) in some countries have remained unchanged and ill-suited to the needs of the new curricula.

The way a curriculum is developed determines in a very substantial degree the conditions of its implementation. The new programmes of science education in the Asian countries were formulated, in nearly all cases, centrally. This did help in concentrating scarce resources of expertise and ensuring qualitative standards, but it also widened the gap between those who developed the curricula and the classroom teachers who are responsible for 'realizing' the curricula in teaching/learning situations—a gap which can hardly be narrowed by the *ad-hoc* association of a few teachers in curriculum activities. Implicit in every curriculum, and the more so in science, are certain teaching strategies, and to the extent that those who are to practise these teaching strategies are unaware of or unresponsive to them, the implementation remains ineffective.

Since the new programmes of science education are only now entering the wider implementation phase in most Asian countries, the experience of implementation is not quite as extensive as that of curriculum development. Nevertheless, some indications are available about the directions in which solutions are being sought to the basic problem of finding a balance between centralized and decentralized curriculum development and implementation. In terms of curriculum development, this involves again the question of relevance, the linking of science education to the immediate environment and real-life problems. In some countries, attempts are being made to decentralize the development of curriculum materials relating to certain topics while retaining a core of other topics for development centrally.

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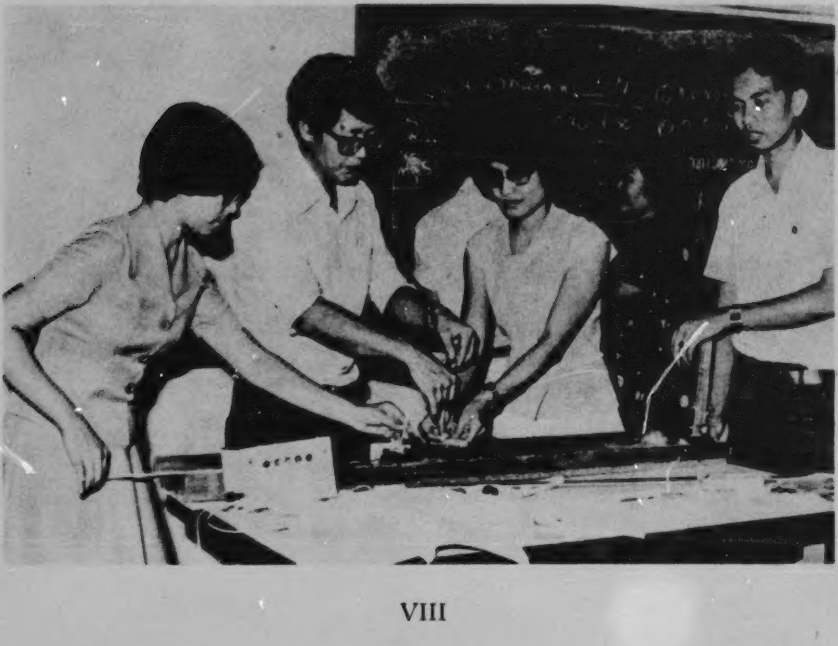
Even in countries where science education curricula are centrally developed, there is a distinct trend towards decentralizing implementation, and networks of regional or district centres are being established in order to achieve this.

Changes in the methods of teacher training have hardly been of a magnitude and depth to match the changes which the science programmes have tried to initiate. Innovations have been made in a few courses, but innovations of the programme itself have not emerged. Nevertheless, there is a growing awareness that the pre-service teacher education programmes have not come up to the challenges of the new school curricula and thus need to be revised.

In order to accelerate the rate of science education improvement, almost all the countries, in the recent past, have organized massive in-service training programmes linked with the curriculum change. The strategy mostly used is to train the key personnel or master teachers, who in turn provide in-service training to teachers. In order to meet the ever increasing demand of in-service training programmes, decentralized resource centres are also being established in some countries.

Despite the extensive in-service training programmes, it is felt that there is an inadequate personal education of teachers, particularly at the primary level, to cope with the changes sought to be introduced by science



VIII

education programmes. Generally the in-service training programmes are designed to help the teachers to handle the specific changes being introduced by a particular curriculum project or to use the instructional materials developed in it. The problem in science education programmes may well lie deeper. By its very nature, science education is more a state of change and evolution rather than a fixed body of knowledge to be imparted. The teacher therefore has to be provided the means and the opportunities for coping with this constantly evolving body of knowledge. The principle of exploration and discovery that holds for the learner of science applies equally to the teacher. Both pre-service and in-service education of teachers could build up and strengthen this 'general' capacity of the teacher to learn, to innovate, to invent.

Another major problem in implementation is created by the examination systems as they are to be found in most countries in the region. The traditional procedures of externally organized examinations are designed to assess a narrow range of cognitive skills and knowledge while the new science education programmes with their stress on enquiry methods, experimentation and application aim at developing skills and understandings which the traditional examination procedures do not encompass. The examination systems however carry such overbearing weight in determining 'success' or 'failure' of students that what is tested in an examination is what a teacher teaches and a student 'learns'. Most of the 'new' science education programmes which were initiated in the 1960s on a pilot scale tended to underestimate the problem of examinations in their preoccupation with developing new curricula and instructional materials. When these programmes reached the stage of system-wide adoption, the examination problem presented itself as a major constraint. The current programmes in most countries reflect a livelier recognition of the need to reform the examination procedures—as an integral part of the effort to reform the curriculum.

The countries in the Asian region have made in the last decade a variety and range of efforts for the qualitative improvement of science education in the schools. Much valuable experience has been gained, which shows in the new questions that are now being raised. Can a reform of science education be carried out in any fundamental way without a reform of the whole curriculum? Can the curriculum be reformed in any meaningful way without examining the social purposes it is to serve? Can the problems of science education be treated in isolation from the larger problems of development which bear on the total educational endeavour —the problems of deprivation, inequalities, quality of life? To the extent that answers to questions such as these are to be found in the current science education programmes, the 1970s may well become a watershed dividing the preceding decades of imitative models from the current efforts. Science education in Asia today is marked by a new awareness of national capacities for self-reliant growth in the search for solutions to problems which have their roots in the particular situation in each country.

SECTION TWO

SCIENCE EDUCATION IN ASIAN COUNTRIES

Bulletin of the Unesco Regional Office
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AFGHANISTAN

The present situation

In Afghanistan, owing to the lack of equipment and facilities, science is taught theoretically in both primary and secondary schools. At the second level, however, efforts have been made to meet the demand for equipment and facilities; thus in most secondary schools science teaching is also done practically. Schools that suffer most from this lack of facilities are schools situated in the more remote regions of the country. It is the aim of the Ministry of Education to remedy this situation gradually and within its budgetary resources.

The Government of the Republic of Afghanistan has undertaken to give access to education to all children, and to provide free education from the first to the third level. Formerly, the structure of the education system consisted of compulsory primary education in grades I to VI, and 'lycée' (secondary education, grades VII to XII). Under the Educational Reform adopted in January 1975, primary education is now compulsory up to grade VIII.

The six-year cycle of primary education was found insufficient, and students completing it did not attain the degree of physical maturity and self-reliance necessary to contribute to their society. By extending the primary cycle to eight years, the Ministry of Education hopes to acquaint the students with local trades and vocational callings. The reform in primary education is biased towards pre-vocational and practical work. The reform envisages a sieving process at grade VIII by way of an examination to determine the students who will be able to go on to the lycées and those to the vocational secondary schools.

General secondary education (lycée) under the reform has been increased in duration from three to four years. In the tenth year there will be a further division of students with one-half being tracked into the science stream and the other half to the social sciences. The number of lycées will be decreased, and about 50 per cent of the student body will be diverted into vocational secondary schools. The reform accords weight to expanding facilities for technico-vocational and technical schools. The establishment of new vocational schools will take place after the completion of the national survey recently underway to determine their types and location. As Afghanistan is predominantly an agricultural country, the number of agricultural schools will be increased and, in addition, schools for veterinary medicine, public administration and nursing will be established. The draft curricula of vocational education will be completed in accordance to the requirements of the reform and the goals set for the economic, social and cultural development of Afghanistan.

A further streaming or sieving process takes place at the end of the 12th year when students from the lycées sit for the university entrance examination. Students receiving good grades are streamed to the sciences, social studies and teacher training.

The planning mechanisms for science education

A technical board operates within the framework of the Ministry of Education. This board is composed of senior technical and scientific personnel of the Ministry of Education, the University and other specialists outside the Ministry of Education. The board determines, clarifies and establishes educational curricula and training programmes. The plans and programmes for science education and technology education are decided upon by this board in accordance with the Educational Policy of the country. The Planning Department of the Ministry of Education is staffed with educational planners and administrators and, in co-operation with the specialized departments of the Ministry, undertakes to formulate education plans and programmes. The Department of Planning of the Ministry of Education co-ordinates the planning activities of the Ministry.

The expenditure required for the improvement of science teaching in Afghanistan is a great burden on the Ministry of Education's budget. It is the budgetary aspect of science teaching which at present is the main problem.

Science education at the first level. At the first level, science is taught in the following manner:

1. In grades I-III, fundamental science is taught as general information in the language books. A teacher's guide provides detailed instructions for teachers on the methods of teaching science through language.
2. From grade III onward, science and health are featured in the school curriculum as separate subjects with time allocated to them in the school timetable. Specific textbooks and teacher's guides are also provided.

The textbooks and teacher's guides for science subjects were prepared by the Department of Curriculum Development for grades III to VI.

With the extension by the Education Reform of the primary cycle to grade VIII, the preparation of the curriculum, textbooks and teacher's guides for grades VII and VIII has been started. In the new textbooks, greater emphasis will be given to bringing theoretical and practical knowledge closer together.

Science education at the second level. Owing to the lack of laboratory facilities and equipment, physics, chemistry and biology are taught more theoretically in the lower secondary stage. This situation is being improved through the efforts of the National Science Centre which prepares science kits from low-cost and locally available materials. The kits are distributed to schools throughout Afghanistan.

Poor laboratory facilities and scarcity of equipment also affect science teaching at the lycée stage. The better-equipped lycées are to be found in the capital and the provincial centres, but in the remoter areas of the country science teaching is perforce mainly theoretical.

The Science Centre

In order to improve the quality of science education, the Ministry of Education set up the Science Centre in 1970 with the following purposes:

1. To develop new science curricula for the lycée stage of general education;
2. To co-ordinate the teaching of science subjects throughout the country;
3. To ensure the optimum utilization of the science equipment available in the country;
4. To design and develop prototypes of new science equipment from indigenous materials and to manufacture them;
5. To develop tests for the evaluation and measurement of science teaching in schools and training centres;
6. To train science supervisors;
7. To conduct in-service training programmes for science teachers; and
8. To undertake research in science education.

The Audio-Visual Centre

The Audio-Visual Centre of the Ministry of Education prepares models, maps, charts and maths kits which demonstrate various mathematic and biological concepts being introduced in primary schools. The centre works in co-operation with the Primary Education Department in the preparation of materials.

Supply and development of instructional materials

The content and teaching methodology of each textbook are developed in accordance with Educational Policy of the country by experts and Afghan authors assigned to the Curriculum Development Department of the Ministry of Education. Once the textbooks are written they are submitted to a specialized steering committee for approval. Trial materials in each subject are tested out in selected schools for their relevance to the educational and social needs of the pupils. At this stage, the trial materials are distributed to enough teachers and students to provide the project researchers with experimental data and feedback on the materials. Revisions are made when these field try-outs indicate the necessity for change. Once the revisions are made and approved the textbooks are printed and distributed. The preparation of teacher's guides for the textbooks goes on simultaneously with the writing of the textbooks. Teacher orientation programmes are prepared by the Curriculum Development Department in co-operation with the concerned departments. It must be mentioned that, with the extension of the primary cycle to eight years, new textbooks are being prepared to cover the two extra years.

The processes adopted for the introduction of textbooks applies to the introduction and development of teaching techniques, methods and materials in the Afghan education system. In the area of science education, the Science Centre and the Audio-Visual Centre are continuously engaged in action research. On the basis of their findings, materials and equipment are prepared and training programmes improved on a continuing basis.

The laboratories for the lycées are imported from abroad. However, owing to the budgetary limitations of the Ministry the amount of laboratory equipment imported from abroad remains insufficient in comparison to the needs of the schools.

Training of teachers, and research and evaluation

Previously much of the training of science teachers took place abroad through the provision of scholarships. However, with the increase in the demand for science teachers, appropriate training institutes have been established.

The training of science teachers for both the primary and secondary cycles takes place in the teacher training institutions. Science supervisors are trained abroad either through bilateral training programmes or through international assistance. Supplementary training takes place through the organization of seminars and workshops. Opportunities are given to teachers to up-grade themselves through the provision of fellowships and scholarships abroad.

At present there are two research departments within the Ministry of Education. For primary education, the Primary Education Department recently set up a separate department to deal with research and evaluation of primary education. The Curriculum Development Project of the Ministry of Education, which has gained valuable experience in research activities, assists the Primary Education Department. The Science Centre carries out research and evaluation activities in science education for the secondary level.

Emerging trends in science education

In view of the objectives of the reform, a need for reviewing of the present curricula is felt. The emphasis on pre-vocational education at the primary cycle and the extension of the primary cycle to grade VIII require the planning and preparation of new curricula.

The Audio-Visual Centre, in co-operation with the Curriculum Development Project and the Department of Primary Education, prepares new science teaching materials from locally available materials. The Science Centre, in co-operation with the Department of Secondary Education, prepares science materials for the secondary cycle. At present, prototypes in the form of science kits have been prepared by the Centre, and it is foreseen that the Centre will in future undertake the mass production of science teaching materials.

Evaluation of science education is done using traditional methods but new trends, principles and methodologies are being adapted to fit the Afghan context.

There is a general trend toward increasing the number of institutions for science education. The problems faced are the lack of personnel, school buildings and facilities, variation in community needs and problems, lack of expert preparation of textbooks, difficulty of publication, identification of manpower needs, and the financial burden on the Ministry of Education.

The Educational Reform lays great stress on science education (as well as technical and vocational education). The reform was formulated to realize the objectives of the seven-year National Development Plan of the country. Although elements of the reform have been carried out, the important areas of science and technical/vocational education await clearer guidelines for the preparation of the programmes so that they may cater to the manpower needs of the country.

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AUSTRALIA

Federal system

Education is primarily a State Government responsibility, although in recent years the Australian Government has been providing increasing financial assistance to the six States specifically for education; in the case of schools, through its Schools Commission. The Australian Government is responsible for education in the Australian Capital Territory, the Northern Territory and some small island Territories. About 80 per cent of school enrolments in Australia are in government schools. The remainder are in non-government schools which must conform to standards set down by government authorities. The State education systems show some differences in their organizational arrangements, curricula and age/grade patterns.

The education offered in Australian primary and secondary schools follows a general programme with no specific vocational emphasis.

Administration and standards

Administration of each State Education Department has traditionally been centralized to ensure comparable standards of instruction in all its schools. However, against a background of population growth and community development during the last 30 years, there has been a general move to decentralization recently by:

1. The devolution of more responsibility to 'regional' administrations for matters such as staffing and budgetary control;
2. The delegation of more responsibility to schools to develop their own courses within certain guidelines, particularly for primary and junior secondary years;
3. The replacement of junior secondary public examinations (and some final secondary ones) by internal school assessments which are equalized at the system level by some form of moderation or accreditation;

4. The encouragement of greater community participation in general decision-making at the school level through representation on school councils.

Curriculum development

There are some differences in the mechanisms for curriculum development in the States and Territories, but in general they have:

1. A curriculum development unit which works closely with the syllabus and examination boards to produce syllabus guides, curriculum materials and professional advice to teachers. The nature of the service provided by these units has been changing as schools have become more responsible for course development and assessment;
2. A board of studies or syllabus committee for each subject which is taught in all or a significant number of government and non-government schools. The boards and committees report to an overall co-ordinating body responsible for curricula and assessment at primary and secondary levels. Except at senior secondary stage, detailed syllabuses have been replaced by syllabus guides in most systems and, in some, syllabus accreditation committees have been established to approve courses developed in schools;
3. An examination board which examines candidates who sit for public examinations. Moderating committees assess standards in schools in some States to ensure comparability of certificates awarded on the basis of internal assessment.

Planning

Planning for science and technical education is carried out by the appropriate boards of studies or syllabus committees in each State. Membership of syllabus boards and committees usually consists of representatives of institutions for higher education, the Education Department, examiners, industry and commerce, and teachers in government and non-government schools. Syllabuses are kept under constant review. Current interest centres on introducing process-oriented syllabuses.

Although, at present, science and technical subjects are usually separate specializations, more attention is being given to their inter-relation in new curricula. For example, the New South Wales Education Department is expected to introduce a new curriculum plan in 1977, to incorporate related branches of learning in broad courses such as 'Science and Technology'.

The planning resources of Education Departments in Australia are largely absorbed by everyday requirements and short-term needs. There is a growing interest in long-term planning. New South Wales and South Australia have recently established councils for educational planning and research.

In recent years co-operation between Education Departments in the development of curricula has increased. The Australian Science Education Project (ASEP) (1969–1974) was jointly funded by the Australian and State Governments. Teachers' organizations, Education Departments and the Australian Council for Educational Research (ACER)—a non-profit, government-subsidized body—co-operated in its development.

In 1975 the Australian Government established a national Curriculum Development Centre. Among other things it is responsible for the dissemination of information about the ASEP materials and the continued servicing of that project.

Science education in primary schools

The teaching of science at the first level is subsidiary to the acquisition of literacy and numeracy skills and general education. Primary science courses consist for the most part of nature study topics.

In recent years, new syllabuses emphasizing the processes of scientific enquiry have been developed in some States. They continue to concentrate on key concepts or themes, such as: living things; food; energy; growth, change and reproduction; and conservation. Most courses provide opportunity for elementary study in the classic areas of science, such as physics. In the Northern Territory a new science syllabus is being tried in a number of schools with particular attention being given to its suitability for Aboriginal children. At least one State is currently developing an integrated course. The development of integrated science courses for primary schools is in its infancy.

The newer syllabuses advocate a problem-solving, activity-based approach. Pupils participate in experiments, excursions and projects and record their experiences in a variety of ways, including the use of models, charts and collections. There has been a trend towards team-teaching and flexible time-tabling; for example, by inviting art and craft teachers to assist students in science classes to mount displays of their work.

There is current interest in environmental education as an integrating subject in the primary school, particularly through such courses as the American 'M:ACOS' (Man: A Course of Study) programme. This course incorporates Science and Social Studies and is being tried in selected schools in several States. Some schools have flora and fauna collections; others have aquariums, wormeries, ant-colonies or beehives. Both the Victorian and New South Wales Education Departments have an education centre at a major zoo; the Victorian Department also has a 'living science' centre in which children and adults can study behavioural habits and learn how to look after pets. The South Australian Education Department, with assistance from the Schools Commission, is establishing a camp school at which outdoor experiences will supplement in-school learning. Similar ventures operate in other States.

Science education in secondary schools

An inductive approach is also favoured for science education in secondary schools.

Junior secondary years. Within general guidelines, teachers are responsible for selecting the teaching methods and materials to construct the science programme best suited to the needs of the students in their particular school. A variety of textbooks, booklets, sets of cards, and other audio-visual materials are available, many of which have been devised by the teachers themselves.

Broad science programmes, covering interrelated fields, are now preferred to the traditional single-subject disciplines of which physics, chemistry and biology have been the most common. The materials produced for the Australian Science Education Project (ASEP) have facilitated this trend. They are adaptable to individual school programmes and to general studies programmes and are now in widespread use. The themes of the project are environmental, including studies in the areas of biological sciences, social sciences and the interaction of man with the natural and man-made environments. Interwoven with the environmental themes in the ASEP materials is an emphasis on the nature of science and how scientific ideas have worked historically and continue to evolve. The emphasis is on activities relevant to the student's experience and on contact with the external environment for the student's development of concepts. The learning approach is one of active, personal enquiry, self-evaluation, and development of decision-making skills in selecting options stemming from core studies and remedial work. Films supplementary to the ASEP units are included in the Australian Broadcasting Commission's 'Programmes for Schools'.

State curriculum development units have also been active in developing materials to assist teachers in the preparation of courses suitable to the particular needs of their students. In Tasmania, for example, a special

Science Syllabus Committee has developed a grid of reviewed science materials suitable for use in schools. It is classified into the themes of equilibrium, change, energy, classification, and structure of living and non-living things. In the Northern Territory, remedial science programmes for the mentally handicapped have been developed. Integrated science projects in Victoria and Western Australia were important in the development of ASEP.

Senior secondary years. The retention in most States and Territories of external examinations at the end of year 12 has restricted the movement towards diversity and integration of science syllabuses in comparison with recent developments at the First Stage. Science still tends to be studied by the way of the conventional academic disciplines (Biology, Chemistry, Physics etc.), although there is a tendency towards limited integration of subject areas, for example, Earth Science (replacing Geology), Biological Science (replacing Biology and Zoology), natural changes (including the dynamics of living organisms and their environments). In a number of States multi-stranded courses have developed as options in recent years: generally these take the form of limited study of several specific disciplines (such as Chemistry, Physics, and Biology or Geology) as part of the total course. In Victoria, the State Examinations Board is producing new courses and materials in Agricultural and Environmental Science, and in Physical Science, with financial assistance from the Curriculum Development Centre.

In New South Wales and Queensland, co-ordinated attempts are being made to develop inter-disciplinary or integrated science courses. Some States offer courses which cater for the student who will terminate his science education sometime during years 11 and 12, but these are generally not inter-disciplinary or integrated courses. Isolated efforts by individual schools appear to be the main exceptions.

For the most part, overseas materials have been adapted to provide resource materials for courses. For example, *PSSC Physics,*[1] *Harvard Project Physics,* and *Chem Study* are used widely in schools largely in their original form. The American *BSCS Biology*[2] materials have been rewritten by a team of Australian editors, with support from the Australian Academy of science, to produce *The Web of Life*, now the most widely used resource material for senior biology courses throughout Australia. The table summarizes the organization of secondary science education in all Australian States.

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[1] Programme developed by the U.S.A. Physical Sciences Study Committee.

[2] Programme developed by the Biological Sciences Curriculum Study project, Boulder, Colorado.

ORGANIZATION OF SECONDARY SCIENCE EDUCATION IN AUSTRALIAN STATES

STATE	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	CERTIFICATION AND ASSESSMENT
Queensland		INTEGRATED SCIENCE Not optional 5–6 periods/week		Optional 5–6 periods/week		Combined Science Biology Chemistry Earth Science Physics	Junior Certificate, internally assessed, externally moderated at the end of Year 10. Senior Certificate, internally assessed, externally moderated at the end of Year 12. Tertiary entrance based on Senior Certificate and Tertiary Entrance Score. Certification controlled by the Board of Secondary School Studies.
New South Wales	INTEGRATED SCIENCE Not optional 5–6 periods/week					Biology Chemistry Geology Physics Integrated Science Agriculture Engineering Science	School Certificate, internally assessed, externally moderated at the end of Year 10. Higher School Certificate gained from external examination at the end of Year 12. This is basis for tertiary entrance. School Certificate controlled by the Secondary Schools Board and the Higher School Certificate controlled by the Board of Senior School Studies.
Victoria	INTEGRATED SCIENCE Optional 2–5 periods/week		Optional 3–5 periods/week			Biology Chemistry Geology Physics Environmental Science	Individual schools assess and report on students' achievement up to Year 10. Higher School Certificate gained from external examination at the end of Year 12. This is basis for tertiary entrance. Certification controlled by the Victorian Universities and Schools Board (VUSEB)

ORGANIZATION OF SECONDARY SCIENCE EDUCATION IN AUSTRALIAN STATES (cont'd.)

STATE	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	CERTIFICATION AND ASSESSMENT
TASMANIA	INTEGRATED SCIENCE Not optional 3 periods/week Optional 3 periods/week				Biology Chemistry Geology Physics Environmental Science Technology Terminal Courses		School Certificate is internally assessed, externally moderated at the end of Year 10. Higher School Certificate gained either from internal assessment or external examination (Division III—matriculation). This is basis for tertiary entrance. Certification controlled by the Schools Board.
South Australia		INTEGRATED SCIENCE Not optional 4–5 periods/week		6 periods/week	Biology Chemistry Earth Science Physics Integrated Science		Individual schools provide a leavers' statement for students who leave in Year 10 or 11. Secondary School Certificate internally assessed and externally moderated and High School Certificate gained by external examination at the end of Year 12. Certification controlled by Education Department and the Public Examinations Board.
Western Australia		INTEGRATED SCIENCE Not optional 6 periods/week			Biology Chemistry Geology Human Biology Physics Agricultural Science Applied Technology		Achievement Certificate, internally assessed, externally moderated at the end of Year 10. Leaving Certificate gained by external examination (there is a movement towards internal assessment at this level too) at the end of Year 12. This is basis for tertiary entrance. Certification controlled by the Board of Secondary Education

Notes. Reproduced from "Survey of Upper Secondary Science Education in Western Australia" by courtesy of the Education Department of Western Australia. The Australian Capital Territory and the Northern Territory are not included. Until 1975 schools in the Australian Capital Territory followed the New South Wales syllabus. Recent developments in the A.C.T. are described in 1.4. Schools in the Northern Territory follow the South Australian syllabus.

Science education in out-of-school programmes

Most States have out-of-school agencies, attached to the Education Departments, which provide a variety of programmes in various community areas, such as zoos, sanctuaries, parks, and galleries. Out-of-school activities at both first and second levels of education vary from single-day excursions to extended live-in courses of study at outdoor education centres, often involving camping-out. These educational excursions to study native flora and fauna and the geography and geology of the areas support and enrich the normal school curricula.

Vacation or summer schools also exist in most States. For instance, academically–gifted students are selected to attend the International Science School, which is conducted by the Science Foundation of the Physics Department, University of Sydney. Some sessions are televised for the benefit of students and the public during two weeks in the August/September vacation. There are also various competition activities; for example, the Science Talent Search conducted by some State Science Teachers' Associations. Other vacation schools are organized to provide a variety of alternative subjects or approaches for interested teachers and students. Subjects included are science, creative film making, commercial subjects, manual arts, and home economics. Courses are also offered by outside groups such as the YWCA and the YMCA, as well as by some government departments and agencies (e.g. the National Environment Council and the Victorian Youth, Sport and Recreation Department).

Institutional arrangements for science education

Primary schools. A primary school teacher generally supervises one class for almost all subjects, in the same room or area for most of the day. The arts/crafts subjects are usually taught by a specialist teacher in a separate room or area. Some schools are now making increasing use of team teaching, depending on the suitability of the school buildings and the interests of staff.

Secondary schools. At the second level, teachers specialize in one or two subjects, e.g., mathematics and science; this is reflected in the school organization. Specialized rooms and equipment are provided for science, arts and crafts/industrial arts, agricultural and secretarial courses, where these are offered by the school. In larger comprehensive schools, teachers' staff rooms may be designated according to subject specializations.

Supply and development of instructional materials

All Education Departments have either free-book schemes or textbook allowance schemes under which per-capita payments are made to government schools. These schemes generally cover the cost of all basic texts in primary schools and most of the requirements of secondary schools. Most government secondary schools charge a small annual fee for the provision of additional texts, in some cases in the form of a book-hire scheme. In some States, students are required to purchase some of their own texts. All Education Departments provide some form of special assistance for the children of low-income families. In non-government schools, tuition and other fees are regularly charged and students are often required to buy text-books. In most government and non-government schools, equipment fees are charged for the use of consumable materials in home science, woodwork, art, craft and some other classes.

The various Education Departments provide government schools with basic instructional materials, such as science apparatus, chemicals, and art and craft supplies. Non-government schools receive general-purpose government grants which can be used for most forms of recurrent expenditure. Most schools make use of centralized purchasing arrangements to take advantage of bulk-purchasing concessions provided by commercial producers. School fees, donations, and fund-raising efforts are the main source of income in most non-government schools and supplement government finance in government schools. Purchases of education materials are free of sales tax.

Since 1964 the Australian Government has been providing financial grants to the States to help both government and non-government secondary schools construct and equip science laboratories. In the 11 years to June 1975, grants totalling 123.3 million Australian dollars were made.

State Education Departments' curriculum branches and the journals of professional teachers' associations publicize materials which are available to schools. The Curriculum Development Centre is in the process of establishing an Australia-wide information service about current curriculum developments, both local and overseas.

In the last few years, the Schools Commission has provided funds throughout Australia for innovative projects at both the system and the school level. These have included science and technology projects, such as a mobile museum for Tasmania and the formation of a travelling advisory team to help develop an environmental course for Queensland schools.

Teacher training

a) **Pre-service.** Until 1973, pre-service training in Australia was conducted in State government teachers' colleges, although a significant proportion of teacher-trainees attended universities, colleges of advanced education and non-government teachers' colleges. In

1973, all government (and some non-government) teachers' colleges became colleges of advanced education.[3] The colleges of advanced education are autonomous tertiary institutions, which concentrate on providing vocational courses to first-degree level, while the universities pay more attention to theoretical disciplines and cater for research. Courses are mostly of four years' duration in universities and three or four years in colleges. Some technical teacher trainees for schools attend technical and further education institutions.

Pre-service training, particularly in colleges of advanced education, has been adjusted to familiarize prospective teachers with the new curriculum approaches and methods. More attention is being given to practical teaching assignments, stressing child-centred learning and individualized instruction. Specific teacher training for the areas of science and technology is normally provided only for secondary teachers. Although most university courses are divided into specific academic disciplines (physics, chemistry, biology) there is some movement towards the provision of integrated studies and environmental courses. In several tertiary institutions, integrated studies in science and education have been developed in recent years.

The Education Research and Development Committee sponsored by the Australian Government is currently funding a project to develop, test and evaluate curriculum materials for use in the education of science teachers in tertiary institutions. It is a self-help programme involving teachers from all Australian States. Activities undertaken include workshops, seminars, and preparation of work units. The aim is to develop an in-service programme from the materials which evolve.

b) **In-service.** In-service education for practising teachers is provided by a variety of means, both within school terms and during school vacations. In most cases, relief teachers are provided to replace teachers attending in-service courses in school hours. Since 1974, each State, assisted by funds provided by the Schools Commission, has established a committee to co-ordinate in-service programmes for teachers in government and non-government schools. Particular attention is paid to the needs of teachers in isolated areas. The range of in-service courses has been expanded from lectures, seminars and formal sessions to include activity-based sessions: for example, participation in co-operative workshops. The Queensland Education Department has recently initiated vacation programmes for teachers to visit factories and other work places to observe the kinds of employment and working conditions which will be available to their students. A national pilot travel and exchange programme was introduced in 1975 by the Schools Commission to encourage the exchange of information and ideas among teachers about curriculum development and teaching methods.

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[3] The remaining non-government colleges provide about 5 per cent of all pre-service training, mainly for primary teachers.

Since the early 1970s, a number of State Education Departments have established pilot teachers' centres in which teachers can meet to discuss new ideas and objectives; produce, exchange and borrow curriculum materials; and obtain information about research and development elsewhere. Since 1974, the Schools Commission has assisted about 30 centres throughout Australia.

Research and evaluation

A number of bodies associated with educational research and evaluation in Australia have already been mentioned: the State Education Departments, the Curriculum Development Centre and the Australian Council for Educational Research. The Education Research and Development Committee also mentioned previously makes grants to organizations and individuals to support research projects, ranging from pre-school to higher education. Universities and colleges of advanced education, in particular their Education and Social Science Departments—some of which have special centres for educational research—also play an active part. More importance has been placed in recent years on establishing priorities at national level.

Emerging trends for science education

The major trends described in this article are summarized as follows:

- Increased use and development of enquiry approaches, keyed to the stages in children's conceptual development in accordance with Piaget's theories;
- Emphasis on the acquisition of appropriate investigatory attitudes and skills, rather than on closely-directed learning of established facts;
- Concern to develop an understanding of man and his environment;
- The introduction of integrated science courses;

- Increased freedom for teachers to design their own courses, within general guidelines, to meet the individual and local needs of their students.

Integrated curricula

Science has been traditionally treated as an 'academic' field covering specialized subjects such as physics, chemistry, biology and geology, while technical subjects, such as woodwork, metalwork, technical training, crafts and commercial subjects have been taught as vocational or even hobby courses. It is only in recent years that some attention has been paid to the interaction of these subjects, such as in some of the ASEP materials—e.g. 'Pigments and Acidity', 'Making Photos', 'Digging up Evidence'. Integrated science and technology courses are beginning to stimulate interest and are expected to be introduced, for instance, in the New South Wales curriculum in 1977, as an area of study for which schools must provide.

Trends in structural and institutional organization

In addition to those previously described, the following may contribute to the development of primary and secondary science and technology education in coming years:

1. Work-experience programmes which have recently been introduced in a few schools in most States to enable senior school students to extend their education outside the school environment;
2. An enquiry established by the Australian Education Council into the problems of young people leaving school to enter the work force or to proceed to further study;
3. The OECD examination of Australian education in 1976, for which a special topic of study will be the adequacy of arrangements to enable students to make informed career and study choices.

Identification of problems and future plans

With the influx of new science resource materials into the primary and secondary schools in Australia, the main problems are in ensuring that teachers are conversant with the approaches and methods to utilize them properly. In recent years there has been considerable effort in all States to develop new science curricula. Indications are that this experimental, exploratory phase will continue for some time.

The trend to school-based programmes is expected to continue with wider teacher involvement in planning and execution and more community involvement.

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BANGLADESH

The structure of the education system

In Bangladesh, education is a vast enterprise with an extensive structure. In a land of some 75 million there is at present a student population of nearly 10.1 million enrolled in about 45,000 institutions of various kinds, from primary schools to universities. The education system is organized into four stages: primary (grades I–V), secondary (grades VI–X), higher secondary (grades XI–XII in the case of general education and grades XI–XIII in the case of technology education) and the post-higher-secondary (university degree level). The primary stage forms the first level of education and the second level of education is formed of the secondary and higher-secondary stages. Currently, plans are being made to extend the first level up to grade VIII.

The bulk of the education system are: (1) the primary schools, numbering about 36,000 with an enrolment of nearly 7.7 million students, and (2) the secondary schools numbering about 8,500 with an enrolment of nearly 2 million students.* The rest of the student population is enrolled in Intermediate Colleges (Higher Secondary Institutions), Degree Colleges, Vocational Schools, Technical Institutions and the six Universities.

The curricular structure is uniform up to grade VIII where the basic programme is of general education. There is no public examination up to this grade. Diversification of the curriculum is introduced at grade IX, where the students separate into streams for science, commerce, humanities and vocations. The academic programme is intended to be terminal at the end of grade X where the students appear at a public examination, but primarily the programme is directed to the preparation of students for entrance into the higher secondary stage. At the higher secondary stage the academic programme for general education is of two years' duration with a public examination at the end of grade XII; for technology education, the programme is of three years' duration with a public examination at the end of grade XIII. The former programme is not terminal but is designed as a preparatory stage for further education while the latter is terminal in character.

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* In the secondary school system about 6,000 schools have grade levels VI–X, while the rest have grade levels VI–VIII.

Apart from the education system described above, there are about 1,400 institutions of a distinct type, called *madrasahs* which have a total of about 270 thousand students. At present, the *madrasah* education is mainly concerned with religious education and the system is also composed of the four stages of primary, secondary, higher-secondary and post-higher-secondary. Schemes have been drawn up to develop the *madrasah* education on modern lines. The curriculum is being developed to give science and technology education the same weightage up to the higher-secondary stage of the system as in other institutions. In fact, craft courses have already been introduced at lower stages in 157 of the institutions.

The planning mechanisms for science education

The Ministry of Education of the Government of the People's Republic of Bangladesh is the highest authority responsible for planning and developing science education (and technology education) at the first and the second levels of education. The ministry plays its role in policy-making and in co-ordinating the planning of activities which are done at different levels. Responsibility for the operational activities is vested in two administrative organs of the ministry—the Directorate of Public Instruction and the Directorate of Technical Education. The Directorates are manned by senior educationists and professionals. Science education provided at the first and second levels falls under the jurisdiction of the Directorate of Public Instruction.

Developmental activities are initiated on the basis of popular demand and changed needs or circumstances. Recommendations of experts from outside the government are often considered for a project undertaking. The groundwork for planning activities is done by the Directorates, which also act as executors of programmes and projects after these have been scrutinized and finally approved by the Ministry of Education, and in specific cases, also by the Planning Commission.

Science education at the first level

Science education courses at the primary stage and up to grade VIII of the secondary (grades I–VIII) are characterized by the uniformity of the curriculum throughout the country. In the lower-primary classes (grades I–III) the teaching of science aims at the study of the environment through observation, oral description and discussion by the pupils. No text-books are provided up to grade III. From grade IV, text-books on general science are provided and the teaching becomes more formal, covering increasing areas of science subjects through the upper grades.

The curriculum and syllabuses are framed by the Directorate of Public Instruction which appoints committees of experts for the purpose. Textbooks are produced and supplied by the Bangladesh School Text-Book Board, another autonomous body attached to the Ministry of Education. The Audio-Visual Education Centre attached to the Directorate produces teaching aids such as charts and diagrams on a limited scale for use in the schools. The present curriculum introduced in 1962 has changed little over the years. A dearth of trained teachers and the short supply of teaching aids and equipment are the major hurdles against achievement of curriculum objectives. The government has recently constituted a National Curriculum Committee. It is hoped that a new curriculum will be developed to suit the new as well as the future needs of the country.

Science education at the second level

A diversified curriculum for this level (grades IX–XII) makes science a separate course of study from grade IX. Physics, chemistry and biology are taught as separate subjects in a two-year course. For students in the science course, physics, chemistry and mathematics are compulsory subjects of study while they may elect biology from a group of subjects. At the end of grade X the students appear at a public examination conducted by the Education Boards. At the higher secondary stage, students have a wider choice of subject combinations to prepare them for a university degree programme in general or technical education including Medical and Agricultural Education. A public examination is also held at the end of grade XII.

The curricula and syllabuses are prepared by the Divisional Boards of Education which have committees of experts for the job. The striking feature is the similarity of the curricula and syllabuses in all four Boards, although the Boards have authority to devise these on a regional basis to suit their special needs. One feature of the syllabuses for science subjects is that a significant part of the syllabus of a subject is overlapped between the secondary and higher-secondary stages. This is because some laboratory equipment and teaching aids are still common to both the secondary and the higher secondary stages. Shortage of qualified teachers and scientific equipment are serious problems in the course programmes. The Text-Book Board produces science text-books for students up to grade X. For grades XI and XII, text-books are produced on private enterprise. There are no teachers' guides and most of the text-books, which were written 10–12 years back, have not been revised on modern lines. It is hoped that new text-books will be produced when the National Curriculum Board develops a new curriculum

The demand for increasing facilities for science education is steadily rising. At present about 50 per cent of the secondary schools and 60 per cent of the higher secondary institutions offer science courses. Science education is now being imparted, on a limited scale, through radio and television.

Supply and development of instructional materials

The major portion of the equipment and apparatus needed for science education programmes is imported from abroad. Some primary schools get apparatus and equipment through a UNICEF Programme.

The Bangladesh Educational Equipment Development Bureau, described in detail later in the chapter, is engaged in designing and producing equipment under a pilot scheme for science education up to grade XII. The Audio-Visual Education Centre has been producing some science instructional materials such as charts and bulletins, particularly for lower levels. Besides these a very few manufacturers in the private sector are making attempts at the manufacturing of simple scientific equipment for secondary and higher secondary stages of education.

The Bangladesh School Text-book Board is entrusted with the responsibilities for producing and supplying science text-books for students up to grade X. Different experts and authors write text and reference books on science courses for grades XI and XII; the books are printed by various private publishers. In addition, books are also imported from abroad for this level.

Training of teachers and other educational personnel

At the primary (I–V) and secondary (VI–X) levels there is no exclusive and separate programme for the training of teachers of science education. The primary teachers' training institutes include science courses as a part of their programmes. In the teachers' training colleges, teacher education colleges and the Institute of Education and Research there are some provisions for specialization for teaching science in the secondary schools. Also, the Bangladesh Education Extension and Research Institute has a regular in-service programme for secondary school science teachers in different areas such as physics, chemistry, mathematics, biology and agriculture. The Institute for the Advancement of Science and Technology Teaching, along with its in-service training courses for the teachers of higher education in science, conducts an in-service training programme for technology teachers from the Polytechnic Institutes.

Research and evaluation in science education. Many of the teachers' training colleges have their own research and evaluation programmes in science and technology education. The Institute of Education and Research, the Education Extension and Research Institute, and the Institute for Advancement of Science and Technology Teaching also conduct research in this respect.

Trends in science education

Curriculum. In Bangladesh, the need for basic reforms in the existing curricula and syllabuses is widely recognized. The government has constituted a National Curriculum Committee which started its work recently. The Committee will develop curricula and frame syllabuses in the light of the report of the National Commission on Education and in line with government policy. Some of the important issues before the committee are:

1. To fill up the gap between the knowledge levels of a developing country like Bangladesh and those of advanced countries within a reasonably short time. Past experiences have shown that very little success is achieved through mere imitation of other systems;
2. To make educational programmes at all levels work-oriented with due emphasis on vocational education;
3. To develop curricula which will maintain a balance between the various competing branches of knowledge and yet will not overburden the learner;
4. To frame syllabuses for science (and technology) education with relevance to local environment and available resources;
5. To design science (and technology) education in the context of local needs and facilities, so that the graduates of the system can in turn produce further job opportunities. The aim is to reduce the number of unemployed among the educated youth;
6. To reform the *madrasah* education system in co-ordination with the system of general education;
7. To introduce elements of population education into the formal education system.

Methods for preparing teachers. The recent trend in preparing teachers aims at introducing pedagogical courses in general colleges along with other subjects. Pre-service training is emphasized in appointing teachers. Teachers are encouraged to participate in in-service refresher courses periodically.

Inter-relationship between science education and technology education. A background in science education is the prerequisite for entry into technology education. The curriculum for technology education at all levels provides courses in the relevant science subjects. The present curriculum for science education does not incorporate any technology elements, except for a few Industrial Arts courses where metal work and wood work are included.

Utilization of community resources (including community problems as learning resources). Recently a programme called 'Outdoor Education' has been introduced in about 500 primary schools with a view to utilizing community resources as teaching/learning materials. For 60 school days, the children will spend some time in their community studying: (a) the village statistics; (b) agricultural work; (c) skill-oriented craft work (d) local social geography; and (e) health, sanitation and food habits. The programme is intended to be work-oriented and to relate the children to their immediate environment.

Evaluation methods and procedures in science education and technology education. The periodical tests within an academic year and the final test at the end of the year are the means for evaluation of science education (and technology education) programmes up to grade IX. Every individual school conducts these tests on its own. At the end of grades X and XI, public examinations are conducted by the four Boards of Intermediate and Secondary Education.

Development of teaching/learning materials. Recent trends are to produce low-cost simple equipment and apparatus utilizing locally-available resources and materials. The Educational Equipment Development Bureau is taking measures to produce equipment and apparatus for both the first and second levels of education.

At present, steps are being taken to create facilities for the repair and maintenance of educational equipment. Plans are also underway to produce books in Bengali in all subject areas of science and technology.

Trends in structural and institutional organization

Recent thinking on structural and institutional reorganization of the primary, secondary and higher secondary stages of education has been reflected in the report of the National Commission on Education. The primary stage is to be extended to cover grades I to VIII and will be organized in the existing primary schools. This will form the first level of education. In the programme of general education, which includes science education, the second level is to be organized from grades IX and X of the lower-secondary stage and grades XI–XII of the higher-secondary stage. The aim is to make the educational programme at this level terminal in character for a majority of the students. For a smaller number of students the programme will serve as a preparatory stage for further education. The academic programme for the higher secondary stage is regarded as a disjointed course between the secondary and the university levels of education; however, the task of bringing four grades of the secondary and higher secondary stages of two separate institutions under an integrated academic programme of a single institution is a huge undertaking. Accordingly, a number of suggestions have been made by the Education Commission for a phased implementation of the programme after some try-outs.

Identification of problems in the development of science education

Science education in Bangladesh is faced with a number of problems:

a) **Availability of a qualified and trained teaching force.** Because of the limited output of science-educated personnel and also because of lower material reward and social status for teachers than in other professions, science teachers are recruited from among lower strata of scientific manpower, especially at the first and second levels of education. Facilities for the in-service training of teachers of the first and second levels of science education exist, but the facilities provided are too inadequate to make any substantial impact on the teaching force. Follow-up programmes, either through correspondence or continuous guidance by supervision, are non-existent.

b) **Availability of standard equipment, apparatus and teaching aids.** Supply in most of the educational institutions has also been inadequate, and as a result science education has been seriously suffering in quality. These things are not manufactured within the country (except for some simple items of equipment, in low quantity and of poor quality) and import from abroad is very limited because of foreign exchange shortage.

c) **Proper use and maintenance of equipment and apparatus.** Equipment maintenance and replacement are difficult and seriously impair science and technology education.

d) **Availability of standard books, journals and other instructional materials.** Scarcity of literature in the local market in the subjects is seriously affecting science education and technology education in the country.

e) **Existing physical facilities.** The general facilities including laboratory and classroom accommodation in most of the educational institutions are still in short supply.

f) **An unchanging curriculum.** The science curriculum is still geared to the needs of the traditional past rather than to the needs of the present and the expanding future, and has failed to encourage enquiry and initiative among students. This has contributed towards driving out a considerable number of students from school or has left them unequipped for productive work in a modern environment. There has been no worthwhile radical revision of curriculum on a national basis at the first and second levels of education. On the other hand, the revision of curriculum has been a continuous process in the universities. The lack of co-ordination between the first and second levels of education and the university level has created inconsistencies in science and technology education.

Of the total secondary enrolment, a small proportion, about 25 per cent, are enrolled in science education, but plans are being made to raise these proportions. The expansion of facilities in the existing institutions and the setting-up of new ones are two of the measures presently under consideration.

Institute for the Advancement of Science and Technology Teaching

The in-service training courses of the present scheme began as a pilot project in 1966 under the joint co-operation of the Ministry of Education, Dacca University, Rajshahi University, the Directorates of Public Instruction and Technical Education and USAID. This pilot project continued up to 1968. On being encouraged by the effectiveness and success of these courses, in 1969 the Ministry of Education established the Institute for the Advancement of Science and Technology Teaching (IASTT) as an organization to operate in-service training courses for college and university teachers in the subjects of chemistry, physics, zoology, botany, and mathematics, and for polytechnic teachers of various technologies and sciences. The main objective of the project is to enhance the academic background and professional competency of science and technology teachers through in-service training workshops, and to provide improved facilities (books and other teaching aids) to the science and technology teachers through follow-up programmes.

The IASTT-sponsored in-service training workshops are held at various centres in the country. The IASTT as a central office is responsible for conducting and co-ordinating all these workshops, and is planning to establish centres of excellence at suitable colleges, polytechnics and universities. Steps are being taken to train more personnel, at home and abroad, to take part in different phases of this project. These staff members are mainly former participants of the IASTT workshops.

The IASTT training workshops are conducted at the universities and polytechnics where the laboratory and other equipmental facilities are made available to the participants. The IASTT bears the cost of laboratory and other related supplies. Experts and instructors are recruited (on a part-time basis) from universities, colleges and other institutions of the country. There are some provisions for a follow-up programme to implement the training programme effectively.

Several phases of the project were evaluated through questionnaires, direct interviews and follow-up information. In the opinion of the majority of the participants the training programme is fruitful and it helps them in preparing themselves for better classroom teaching.

Through its follow-up programme, the IASTT was able to provide many colleges, university departments and polytechnics with books and teaching-aids (overhead projectors, movie projectors, electrical instruments). The follow-up programme could not be strengthened to the desired level, however, due to lack of funding. Participation of senior teachers in these workshops has been poor. So far, about 1,950 teachers (with some repeats) have attended the workshops.

Bangladesh Educational Equipment Development Bureau

Background. Of the various problems that science education in Bangladesh is faced with, the problem of equipment has remained very acute. The main bottleneck with regard to equipment is the limited availability and supply to the educational institutions, and the improper use and maintenance of equipment and apparatus which is available.

No worth-while attempt at manufacture of equipment within the country has been made so far. Only a few disjointed small-scale workshops have tried to manufacture educational equipment. Equipment and apparatus produced by them have been largely sub-standard primarily due to lack of technical know-how, scientific production methods and understanding of educational needs—and are again very meagre in quantity to meet even partial requirements of the schools and colleges. Standard designs and quality control are virtually non-existent. Import of science equipment, albeit a necessity, results in high prices and considerable drain of foreign exchange.

The Bangladesh Educational Equipment Development Bureau in Dacca was established by the Ministry of Education with a view to developing educational equipment, stimulate local manufacture of equipment to permit savings in foreign exchange and improve the situation regarding use and maintenance of equipment available in the schools and colleges.

The plan for the establishment of the Bangladesh Educational Equipment Development Bureau was approved in 1964; the Bureau started functioning in 1965. The Ford Foundation gave some financial assistance to the project during the initial period of operation. Recently, Asia Foundation, Dacca, has provided some financial assistance in the form of grants-in-aid.

Objectives and functions. In particular, the Bangladesh Educational Equipment Development Bureau has as its mandate the following tasks:

1. To develop educational equipment and take measures to stimulate the manufacture of educational equipment that is in greatest demand and is integrated with the curricula to permit savings in foreign exchange;
2. To set up standard designs and quality control;
3. To make measures to assure that equipment and apparatus available in the educational institutions are fully utilized and properly maintained;
4. To take appropriate steps to improve planning and research in educational equipment, and to gain knowledge about new teaching devices and technological advancements in other countries.

The Bureau presently has the following functions:

1. Improving planning and research in educational equipment;
2. Introducing, through prototypes, designs in educational equipment and apparatus, including laboratory glassware, teaching aids and kits;
3. Promoting local manufacture of standardized educational equipment;
4. Providing designs and advisory services to the manufacturers to improve their skill and understanding of educational needs;
5. Providing quality control and price-standardization services;
6. Preparing standard lists of equipment in accordance with curricula, and instruction manuals and purchasing guides of equipment with specifications;
7. Advising teachers in the use and maintenance of equipment and apparatus available in the schools and colleges.

Educational prototypes of equipment are first developed. Industrial models of educationally satisfactory prototypes are then designed with due consideration given to maximum utilization of raw materials and components available in the country. The prototypes are placed before the subject ad-hoc committee for examination and approval. Later, through private workshops, the Bureau produces standardized science equipment for about 120 selected laboratories in schools and colleges in the country. This measure is aimed to encourage manufacturers to produce these items of equipment in large numbers. These model laboratories are equipped with the view to not only help in raising the standard of science teaching but also to inspire schools and colleges in the adjoining areas, and in due course, to use a small number of them as the satellite in-service training centres for science teachers and laboratory technicians.

Project development. The project scheme includes provisions for foreign training of some of the staff in countries claiming leadership in the fields of these development activities. However, this type of training could not be arranged so far for various reasons, primarily due to lack of funds in foreign exchange. Assistance of foreign aid-giving agencies is being explored in matters of such training abroad. The scheme also provides for the training of personnel in specialized institutions within the country.

A science laboratory and a small quality-control laboratory have been set up in the Bureau for purposes of research and development, try-outs, testing, and quality control of equipment where prototypes and equipment produced locally under the sponsorship of the Bureau are tested, evaluated and their quality inspected. This equipment is also tried and evaluated by the students and teachers in the science laboratories of the schools and colleges receiving the equipment from the Bureau. Groups of science teachers from various schools and colleges are also brought to the laboratories of the schools and colleges receiving the equipment from the Bureau. Other groups of science teachers from the schools and colleges are brought to the laboratory of the Bureau for try-outs and evaluation of the locally-produced equipment.

The Bangladesh Educational Equipment Development Bureau functions under the administrative control of the Directorate of Technical Education. The Bureau presently has a nucleus professional staff consisting of a director and a few subject specialists who together cover such fields as physics, chemistry, biology and industrial arts. The Bureau is guided in its work by an Advisory Committee and several subject ad-hoc committees to ensure its development work in accord with curricula and teaching practices best suited to educational requirements and standards.

The Bureau has achieved satisfactory progress in its objectives. A minimum-requirement science equipment list based on the existing science curricula of the secondary and higher secondary levels of education has been prepared. Designs, complete with specifications, and prototypes of some 150 items of equipment and 35 educational charts have so far been developed. Some 120 items of equipment and 12 educational charts produced locally through private science equipment manufacturing workshops have been given to 120 educational institutions. A quality-control laboratory and a model classroom laboratory have been set up for research, testing, try-outs and evaluation, and quality control of equipment produced locally. Instruction Manuals containing illustrated descriptions and brief instructions on use and maintenance have been developed for some of the equipment. Science teachers receiving equipment from the Bureau are given short training in the use and maintenance of equipment. The manufacturers are being supplied designs and blue-prints of equipment complete with specifications and extended advisory services to improve their skill and understanding of educational needs.

Evaluation of the progress of work and implementation of the project programmes is done at the level of the Advisory Committee of the Bureau, the Directorate of Technical Education and the Ministry of Education, Government of Bangladesh. The evaluating bodies have expressed satisfaction over the progress in work and over-all achievement in the project programmes and have recommended that this development project should continue on a permanent basis with necessary expansion in its facilities.

Problems and successes. Apart from the efforts of the Bureau, there has been no systematic and organized effort, either in the private or in the public sector, at design or local manufacture of educational equipment with adequate finance and technical know-how. There is no equipment designer in the country. The few workshops that have been making attempts at manufacture of science equipment are small workshops whose machinery is poor and not made for the manufacture of science equipment. These manufacturers do not understand educational needs and science principles. There is a shortage of skilled workmen oriented in the manufacture of educational equipment. Workmen employed at these workshops have no formal training in instrumentation and generally cannot read and understand technical drawings. There is little concept of tooling and the manufacturers lack modern production techniques to be competitive. Inspection and testing of equipment, quality control and price standardization are non-existent. Raw materials and components needed for fabrication of educational equipment are not always available in the market. Manufacturers often face difficulties in importing raw materials, components, machineries, jigs and dies because of foreign exchange limitations. The existing system of procurement of equipment with the schools and colleges acting as disjointed purchasing units has not

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only failed to exert influence and compel the manufacturers to produce quality equipment, but has failed to reflect to the manufacturers the true demand pattern. Manufacturers have been reluctant to undertake mass production of equipment without some sort of market guarantee.

Despite these problems, the Bureau has been able to demonstrate to some manufacturers the usefulness and need of the practice of standard designs, inspection and testing of equipment, and quality control. Manufacturers are also accepting advisory services from the Bureau to improve their production technique as well as understanding of educational needs. Some manufacturers, in co-operation with the Bureau, are successfully producing educational equipment in full conformity with the designs and specifications drawn by the Bureau. It is therefore possible to manufacture locally equipment of standard quality—a situation not experienced before. Confidence now prevails among the manufacturers that, given proper assistance and encouragement, much of the educational equipment for schools and colleges can eventually be produced in the country.

A proposal for expansion of the project has been submitted to the government. Provision has been included for raising buildings for offices and a workshop, on a permanent site, and extension of other facilities, including staff. The expansion programme would include activities in matters of design and development of educational equipment and toys for the primary stages of education, besides those for secondary and higher secondary education. The programme includes concentrated and effective activities to be taken by the Bureau towards the promotion of local manufacture of educational equipment for all levels of education. The proposed workshop would be used for (i) prototype making and (ii) pilot production and would act as the pilot production unit in offering leadership to the country in matters of manufacture of educational equipment. It has been proposed that the Bureau be given authority to act as the co-ordinating and regulating agency for organizing and controlling production of science equipment.

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BURMA

Present state of science education

The present structural pattern in the school system of Burma is 5-4-2; i.e., five years of primary education, four years in the junior secondary stage and two years in the senior secondary stage. The school admission age for primary school is 5+.

A separate Curriculum and Textbooks Committee has been formed under the General Education Council to formulate the policy for curriculum development and teaching materials production. For the co-ordination of curriculum and textbook preparation, a special section for curriculum development and planning has been established in the Department of Basic Education.

There is a sub-committee for each subject to deal with matters concerning syllabus, students' texts, teachers' guides and teaching aids. The Science Syllabus Sub-Committee is comprised of the following:

- Academic staff from the Department of Higher Education;
- Teacher educators from the Institute of Education (University-level) and teacher training institutes and colleges;
- Staff from the Curriculum and Textbooks Section, Department of Basic Education;
- Representatives of classroom teachers;
- Staff from the School Inspection Section, Department of Basic Education; and
- Staff from the Burma Educational Research Bureau.

Science education at the first level

There are two types. For the lower primary stage (i.e. from K.G. to grade II) science education is introduced as part of the 'Environmental Studies' course. There are no textbooks for these classes but there is a teachers' guide. For the upper primary stage, science education is taught as 'Basic Science'. The present syllabus for primary education was introduced in 1967. The content of teaching/learning material is extracted from pupils' daily experiences at home and from their environment.

Science education at the second level

At the junior secondary stage, science education is in the form of 'General Science', while at the senior secondary stage, science subjects offered are 'Natural Science', Physics, Chemistry, Biology, Geology and Agriculture. The present syllabus for the second level was also introduced in 1967.

The General Science syllabus has been developed with the emphasis on Earth Science in grade V, Biology in grade VI, Chemistry in grade VII and Physics in grade VIII. The salient feature of science education at the second level is the specialization after the junior secondary stage: only students who show special aptitude for science are allowed to study science courses at the senior secondary stage.

The senior secondary students who are allowed to study science have a choice between Geology, Biology or Agriculture as an optional subject.

Out-of-school science education for youths is developed through hobby clubs such as aero-modelling clubs, marine youth clubs, junior farmers' club and voluntary work camps during summer vacation sponsored by the Lanzin Youth Section of the Burma Socialist Programme Party with the assistance of the departments concerned.

Organization

The organization and institutional arrangements for science and technology education in schools are under the direct control of the Department of Basic Education with a deputy director as its head. In fact this director is head of the academic wing of the Basic Education Department. The academic wing of the Department of Basic Education has four sections:

1. Curriculum Development and Planning Section;
2. Teacher Training Section;
3. School Inspection Section; and
4. Students Affairs Section.

Regular evaluation and inspection of science (and technology) education in schools are carried out by inspection teams by State or Division.

The final examinations after junior secondary and senior secondary stages are held by separate Examination Boards, and the examiners are either recommended or selected by the Department of Basic Education.

The supply of science (and technology) equipment is done in three ways:

1. A university science workshop, set up for the manufacture of school science apparatus, distributes finished products to schools through the Department of Basic Education. Raw materials for this workshop, not available locally, have been supplied by UN bodies such as Unesco and UNICEF.
2. Some apparatus, such as electrical machinery and tools, are sometimes imported.
3. Teachers themselves sometimes develop their own science teaching aids. Their ideas may be copied from school to school through science exhibitions.

Teacher training

Teacher training in Burma is at two levels—degree-level and undergraduate-level. The Institute of Education, a university-level institute, trains senior secondary teachers while teacher training institutes and schools train junior secondary and primary teachers.

Since teacher training institutes and schools are under the supervision and administration of the Deputy Director (Academic), the Department of Basic Education and their teacher educators are also members of syllabus committees. The teacher training programmes are always in tune with the latest trends of curriculum development. So far, a total of 440 teachers have had their in-service training in industrial arts, domestic science and agriculture.

The Burma Education Research Board is doing national scale research in education in different fields, but other institutions such as the Institute of Education, Teacher Training Institutes and the Curriculum Development Section are also doing small-scale research work in education.

Under the auspices of a science syllabus sub-committee the staff of the Curriculum Development Section are carrying out an opinion survey of teachers on their about-to-be prescribed new science course, and a programme of research for the analysis of types and nature of errors made by students in their science examination papers have been submitted for approval.

Currently emerging trends in science education

A new basic and general science syllabus has been approved and a set of students' texts, workbooks and teachers' guides have already been written. The objective of this new syllabus is to enable those students who will not go further than primary or junior secondary stages to understand and practise basic health; to lay a firm foundation for further study in their senior secondary stage and technical subjects; to develop their reasoning habit to reach correct decisions in life.

The new science syllabuses for primary and junior secondary stages are developed according to a 'spiral' method. There are 12 main topics throughout the course in each class. The content of teaching/learning material is chosen to suit the mental and physical development of the children and the national needs. The texts are written so that there is a relationship among subject matter in the same topic as well as those in other topics. The main teaching method recommended in teachers' guides is the discovery method but each individual teacher is at liberty to use the method he deems suitable.

The new basic and general science texts and workbooks demand children's active participation thereby eliminating the age-old situation of being passive recipients of knowledge on the part of children. This helps a great deal in specialized education where effective learning can only be achieved by doing.

As regards subject matter, the biological science portion is included in such a manner as to help the agricultural and domestic science classes. The skills required in industrial arts classes have been developed by science practical classes.

Burma is basically an agricultural country and naturally most community problems are agricultural, such as crop failure due to natural disasters and pests, health problems such as malnutrition or contagious diseases, and international problems such as the energy crisis. The science syllabus and texts have chapters on these problems and their possible solutions. The evaluation or inspection teams are now being provided with systematic and concise forms and effective methods of inspection.

There is a direct relationship between the primary stage and junior secondary stage science education but, for the senior secondary stage, there is no longer general science but physics, chemistry, biology, geology and agriculture.

The problems encountered in the development of science education are varied and many. The first main problem is a shortage of material; i.e., shortage of printing material for texts, raw materials and tools and equipment for science and industrial arts. With a rapidly-growing student population and sudden awakening of technology education consciousness, it is found very difficult to cope with the supply of above material.

Another main problem is that too much weight is given to examination results at the senior secondary stage. As practical examinations cannot be held in the final examination together with their written papers, students lack enough enthusiasm for science practicals.

A third major problem is shortage of trained personnel as well as reference books for the curriculum development section.

There may not be any drastic change in science education at the primary and junior secondary stages in the very near future, but the specialization of science and arts courses is under consideration.

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INDIA

Present state of science education

The structure of the education system in India is passing through a process of change. The Education Commission (1964–66) had recommended a structural change along with other important recommendations concerning schooling facilities, management of schools, curriculum and teacher-training. The new structure follows a 10+2+3 pattern. It means that the first ten years in a school will be followed by two years of higher-secondary schooling, after which the students may go in for the first three-year degree course.

The Commission had recommended that it is at the higher secondary stage that a large bulk of students be diverted to vocational courses and, in order to facilitate the process, work experience should be made an integral part of the school curriculum in the first ten years. There is a broad national consensus on this issue among the various States of the Indian Union. Most of the States have already initiated this pattern of schooling and it is expected that shortly all of them will have this uniform pattern of school education.

The division between the first and second levels of education in school is not rigid but varies somewhat from one State to another. The primary education in most States consists of the first five years of schooling. In between the secondary and primary stages, a middle-school stage is interposed in many States. In the national curriculum framework, following the recommendation of the Education Commission, grades IX and X have been considered as the lower secondary stage and XI and XII as the higher secondary stage. In presenting this report, by 'first level' we mean grades I–VIII, and by 'second level' we mean grades IX–XII.

It may be seen that school education is a State subject in India. The National Council of Educational Research and Training (NCERT) acts as an advisory body. The NCERT is concerned largely with the improvement of the quality of education in the schools. In the field of science education, it is the national body for developing curriculum textbooks, instructional materials, teaching aids, laboratory equipment, evaluation methods and teacher training. The NCERT works through editorial boards, working groups and special advisory groups with which are associated specialists from various disciplines from universities and other institutions of higher learning, the State Institutes of Science and school teachers. The development of curriculum, instructional materials and other plans are thus based on broad consensus and co-operation.

Science education in India has been developed in pursuance of the Science Policy Resolution, which was one of the most important contributions of Jawaharlal Nehru, late Prime Minister of India, for nurturing scientific research and education in this country. We have the Council of Scientific and Industrial Research which is largely concerned with the implementation of the Science Policy, and the National Committee on Science and Technology, an apex body, concerned with broad formulations of policies.

Science education at the first level emphasizes the idea that *Science is doing*. With the assistance of Unesco, suitable curriculum textbooks and instructional materials and teachers' guides were developed by the NCERT. In addition, the NCERT has involved a large number of experts in physics, chemistry, zoology, botany and mathematics to produce suitable instructional materials. A science kit for the first level was produced by the NCERT after field trials, and is now made available to the States through Unicef assistance.

The new approach in science education at the first level, according to the nationally approved framework of the ten-year school curriculum, is to teach science as an environmental study, making it inter-disciplinary in approach, with focal points on problems in the environment of the child.

The main emphasis at the second level of education is on improving the content of science. At this stage, each science is taught as a discipline and there is an emphasis on methodology using laboratory experiments. In the new curriculum, this is now likely to be inter-disciplinary and pure subject orientation will be introduced only at the higher secondary stage; i.e., grades XI and XII.

So far as the extra-curricular programmes (no out-of-school science education for drop-outs or adults is reported–*editor*) are concerned, the dissemination of science education is done mainly through the activities organized by science clubs in various schools. In most of the States, the schools are encouraged to participate in district or State-level science fairs. The NCERT organizes National, State and a few district-level science fairs at various centres. These provide the forum for the bright and creative children to present their models, innovations and projects of various kinds.

Talented students of science are selected for the National Science Talent Search Scholarships by the NCERT. They are also given an opportunity to attend regular summer courses at various colleges and universities and also at some centres of research. They are exposed to an enrichment programme in science beyond the school curriculum and are encouraged to develop their own scientific projects under supervision of specialist guides.

The curricula, textbooks, instructional materials, teaching aids and science kits are produced at the NCERT and handed over to the various States for translating into State languages and use in their school systems. A number of University Departments of Physics, Chemistry, Biology, Mathematics, and some other institutions like the Tata Institute of Fundamental Research, also produce similar materials. At the State level, there are State Institutes of Science Education which are gradually being amalgamated with the State Council of Educational Research and Training in most of the States. They are largely concerned with in-service teacher education for the new curriculum and instructional materials.

In almost every State in India, there is a State agency for publishing textbooks. These publishing agencies print and distribute the first- and second-level textbooks, teachers' guides and manuals within the State. In the cases where the NCERT textbooks and guides are used by the States they are translated into the State language and then printed by the State-level publishing agency.

As regards the laboratory equipment for the teaching of science, efforts are being made to minimize the dependence on laboratory apparatus at the first level. Through UNICEF assistance, science kits have been supplied to various States for their teacher training institutions where the student-teachers will learn the use of these kits. The kits are also sent to some schools to be tried out. Private manufacturers are also encouraged to produce kits according to the designs and specifications of the NCERT.

In primary education a teacher is trained for all subject areas. There is no special training programme for a science teacher. About 1,200 training schools throughout the country train teachers for the primary classes. Usually the training is content-oriented and covers all subjects including science as well as methodology. For the second level, the science teachers are specially trained by about 300 teacher-training colleges spread across the country. The minimum requirement for entry into these colleges is a degree in science. The training programme for a year is mostly restricted to the principles of education, child development and methodology of teaching. It is presumed that the content area is already known to the teacher trainee. There are four Regional Colleges of Education which provide a four-year integrated course of content-cum-methodology to the trainees who have completed a higher secondary diploma.

Research and evaluation of the science (and technology) education at the first and second levels are also carried out by various agencies. Financial assistance is made available to the research workers in universities, training colleges and other institutions of higher learning from various sources including the NCERT. Previous research in this area was concerned mainly with achievement testing. There has been a change during the last few years, however, and increasing attention is now being given to an understanding of the development of concepts of science and technology in children as well as to the methods of teaching and learning.

Trends in science education

With the realization of the importance of science as an integral part of life in a developing country where improvements in technology, health practices and industrialization are taking place in rapid succession, there has been a growing awareness of the significance of the science education programme at the school level. The main trends and objectives that are emerging may be enumerated as in the paragraphs below.

At the first level, the curriculum in science emphasizes the teaching of science as a set of environmental studies. In the first two classes in the school it begins as a composite course including both the natural and the social environment, but in later years, it is diversified into two subjects: (a) environmental studies based on natural science, and (b) environmental studies based on social science. The emphasis is not on specific topics to be covered in a syllabus lest the students' minds be cluttered up with dry facts and information only. The objective is to sharpen their senses and train them to observe their environment and enrich their experience. The science curriculum has been based on the environment around the child so as to make it interesting and meaningful. The content of science knowledge is not built on abstract concepts alone, but also on the solid foundations of experiences drawn from the environment of the child. In such a programme an inflexible syllabus cannot be drawn up for all schools in the country. During the first part of schooling it is not advisable to provide science textbooks—which usually have an urban bias. So the teachers are provided with guides and they develop their own instructional materials. The reading materials for children, however, should be thoughtfully prepared in order to motivate them to learn.

The environmental studies also offer the opportunity for an interdisciplinary approach and this approach is emphasized up to the end of the first level of education. At the second level, the separate disciplines of physics, chemistry and biology may be introduced.

In the preparation of instructional materials and teaching aids, two expert groups have been set up, one for the first level and the other for the second level of education. These groups are inter-disciplinary in character and have members from the universities, NCERT and the State system of schools. Science films, filmstrips and other such materials are also being produced and supplied in packages, along with certain test materials. The teacher's guide explains how to utilize effectively the multi-media package of educational technology along with other instructional materials. This is a new development in which the Centre for Educational Technology is playing an important part.

As the curricula are modernized, the child has to learn more during a limited time; therefore, the use of new audio-visual aids and improvement of techniques are also needed. Thus, the present trend is to train future teachers in the new techniques and in the use of various kinds of audio-visual aids.

Apart from the improvement of the pre-service training of teachers, it is also common to have periodic in-service courses for the teachers who are already on the job while, at the second stage, the in-service training programmes are mainly aimed at updating the content of science. For the teachers of primary- and middle-level schools, the emphasis is on methodology teaching, integrated with the content. The teachers are also trained in the various manual skills of experimentation, developing innovations and handling of audio-visual aids.

The approach to the teaching of science in the new curriculum of the ten-year school will include knowledge of technology. Work experience is one of the important features of the new curriculum. Towards the end of the first level, work experience is likely to be oriented more towards technology just as the environmental studies approach in science will involve the technology in use in the life around the child. In the higher secondary stage; i.e. in grades XI and XII where science will be taught as disciplines but where an attempt is being made to divert a large number of students to vocational courses, the dichotomy between technology and science education will disappear. Only those students who will pursue studies for joining the universities will study pure sciences as separate disciplines.

There is nothing special about the methods of evaluation in science and technology. It will follow the same pattern as for other subjects in the schools. The new method is concerned with increasing internal assessment on a continuous basis. The final public examination will use letter grades instead of percentage marks. There is a strong opinion against declaring any student a failure.

The general trend in the institutions and organizations for science education in the country is to bring about increased collaboration from the university and research scientists in the field of curriculum development, not only at the central but also at the State level. The NCERT is developing a well-staffed Department of Education in Science and Mathematics for providing leadership at the central level. At the State level, some of the State Institutes of Sciences and Science Centres are planned to provide local leadership. A large number of *Nehru Yuvak Kendras* have been established for providing opportunities to students for out-of-school science activities. A network of children's science and hobby centres are being developed at the State level. Increased collaboration is becoming available from the State museums for training teachers in creative and constructive activities in the field of science.

Problems in the development of science education

The foremost problem is that of providing necessary equipment to make science teaching really experiment-based. While attempts are being made to make use of indigenous kits and innovations, the importance of conventional apparatus and equipment for the second level–where science is mostly taught as subject disciplines–cannot be over-emphasized.

A second problem is that of the training of teachers. Even though the curricula and instructional materials may be improved and brought up to date, the vast majority of teachers, particularly the old teachers, have a comparatively poor knowledge of science content and therefore need the basic content of science before they are able to handle the improved curricula. This has necessitated the organization of a very large number of in-service courses. The problem is not only how to cover the curriculum content in a limited time, but also how to provide an adequate number of trainers for such courses.

Third, the teacher training courses for the pre-service programmes need a complete overhauling so that during the training itself the teacher not only has an up-to-date knowledge of science but also adequate skill to impart this to the students.

Fourth, there is the problem of changing the attitude of the conventional teachers towards the teaching of science. They have to realize that it is not the textbook and the laboratory which provide all knowledge but the whole environment is to be used for the students' learning experience. The attitude of working with their hands in preference to their brains is also important.

Future plans for science education

In the plans for science education, the main emphases are on the following:

1. The development of improved instructional materials in terms of present-day knowledge of science and their application in everyday life;
2. The preparation of simple, indigenous equipment and kits to provide adequate learning experiences to students, even when conventional laboratory facilities are not available;
3. The development of audio-visual aids and graphic materials to make learning easier;
4. The improvement of pre-service teacher training curricula to include more practical work in science in relation to the content area that the teacher has to teach in the classroom;
5. The development of opportunities for out-of-school science activities for students and encouragement of constructive and creative abilities of students by organizing science fairs at district, State and national levels;
6. The development of simple supplementary reading materials in science suited to the age level of children;
7. The in-service education of teachers on a continuous basis and through various methods, utilizing the resources available with the State agencies, the Central Government and the universities.

A PROJECT FOR THE IMPROVEMENT OF SCIENCE EDUCATION AT ALL LEVELS OF SCHOOL

Target population and scope

This project has been undertaken in three phases after the initial development of instructional materials. The first phase is a pilot one wherein the developed syllabuses and instructional materials have been tried in a limited number of schools in various States and Union Territories of India. The second phase is a wider implementation of the programme envisaged in 5 per cent of the primary and 33 per cent of the middle schools in the country. The final phase is universalization of the programme in all schools. In the pilot phase, the target population at the primary and middle school stages and in the wider expansion phase were about 90,000 and 1,774,000 respectively.

Initially it was an experimental project for developing syllabuses, textbooks and teachers' guides for the primary and middle stages. The developed instructional materials were tried-out on an average in 30 middle and 50 primary schools in about 19 States and Union Territories. The original materials were developed in English and translated through State collaboration into all the 12 languages of the country.

After the initial tryout and feedback, wider expansion of the programme was taken up and the scheme now covers nearly 25,700 primary and 18,000 middle schools all over the country.

The third phase is the universalization of the programme in all the States. So far, six States and four Union Territories have adopted the new curricular materials for all the schools in the States/Territories. The total number of schools covered at the primary and middle stages are nearly 200,000 and 45,000 respectively.

Background and objectives

The initial programme of developing instructional materials was taken up in 1966 and the first drafts for all the stages were completed by 1969. The pilot project was started during 1969–70 in the States and Union Territories of Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, Delhi and Pondicherry and was completed by 1973–74. The wider expansion phase commenced in the above States and Union Territories in 1973–74 and it is still continuing. Other States which joined the pilot phase in 1973–74 have also entered in the wider expansion phase.

The main problem is to bring about consistency in the up-to-date science content, suiting the present-day requirements of the children at the primary and middle stages. This requires the preparation of instructional materials and development of teaching aids, which implies the training of teachers who do not have the background needed for handling the improved curricula.

The main objectives of this project are to bring about overall improvement of science teaching in schools through a phased programme. Some specific aims are noted below:

1. To develop improved curricular materials, including syllabuses, textbooks, teacher's guides, kits and kit guides for different stages of instruction in schools;
2. To train the State-level key personnel who would be responsible for the in-service training of teachers involved in the project;

3. To upgrade the teacher training courses for equipping the teachers to effectively handle the new curricular materials;
4. To equip the teacher training institutions with laboratory equipment and facilities to enable them to organize pre- and in-service programmes more efficiently.

Project design and implementation

The project design includes the following phases:

1. The development of model instructional materials in the Department of Education in Science and Mathematics of NCERT, and through various Study Groups established at the universities by the NCERT. These instructional materials are developed in collaboration with content experts, teacher educators, scientists and classroom teachers and the materials are tried-out in a limited number of schools in Delhi to find their suitability in the classroom;
2. The development of the prototypes of simple indigenous science equipment and kits to enable the teacher to perform demonstration experiments in the classroom as required by the curriculum and to manufacture a limited number of such equipment for a try-out in schools;
3. Training of the key personnel from the States at the centre.

In all this developmental work, expert assistance was available from Unesco. After the development of materials, the next phase was its implementation in various States. For this phase, programme assistance from UNICEF was available and the strategy was to involve the States that volunteered to take up the project. In this phase, the following steps were taken.

The willing States had first to translate and adopt or adapt the instructional materials on a pilot basis in about 30 middle schools and 50 primary schools. The project funds were provided for the cost of translation and printing of the trial edition of textbooks and teachers' guides which were provided to the students of the experimental schools. The in-service training of the teachers was also financed from the project funds. Each school was provided with the necessary number of science kits. The feedback obtained from the pilot phase was used to revise and define the instructional materials as well as the training programmes.

Based on the experiences of the pilot phase, the States were assisted in implementing the scheme on a wider scale. The assistance was limited to about 5 per cent of the primary schools and was expected to cover 24,000 primary schools and 33 per cent of the middle schools so as to cover 31,000 middle schools. These schools were to use the revised instructional materials from the pilot phase. Each school was provided with the necessary number of science kits and 50 per cent of the cost of training the teachers was provided out of the project funds.

The last phase is universalization of the programme in all schools of a particular State or Union Territory. It is hoped that the assistance provided at the pilot and wider expansion phases would be a catalytic one for the State to introduce the improved programme of science teaching in all the schools on a universal basis through its own resources.

The whole project does not need any existing institutional or structural change except that the State Institute of Science Education or its corresponding unit was to be responsible for the supervision of the programme in that State. It was, however, envisaged that for the wider expansion and universalization phases, the States would locate district-level science supervisors from their existing inspecting staff who could be adequately oriented to provide constructive help and assistance to the schools in implementing the new curricular programme.

At the central level, the NCERT concentrated on developing key personnel from the States, including the staff of the State Institutes of Science Education, so that the State-level leadership was responsible for the implementation of the project, training of teachers, getting feedback from the States and constant revision and refining of the materials.

The organization strategy was to make the State-level institutions the local leaders for disseminating the theory and approach of the project in the State. At every stage of development and try-out, the collaboration of State-level agencies has been sought by the NCERT. Thus, a climate of change has been developed in the States. The success of the project can be estimated from the fact that, even though voluntary, the pilot phase has been completed in 19 States and 3 Union Territories and is still continuing in two more States. The wider expansion programme has been taken up by about a dozen States and five Union Territories. The universalization of the programme has progressed in six States and four Union Territories.

Problems

The major problems and constraints are noted below:

1. The widely varying school structures and languages in various States affects a proper adaptation of the model materials developed in the NCERT by the States.

2. The teachers in service are not adequately equipped to handle the up-to-date content curriculum in science, particularly at the primary stage. For this an intensive programme of in-service education for the teachers is necessary.
3. The available equipment and facilities are not enough for making the teaching of science experiment-based. Conventional apparatus and equipment are difficult to get for the vast number of primary and middle schools throughout the country. Hence, there is the need for innovations and improvization in the form of science kits.
4. The pre-service training of the teachers, particularly for the primary school stage where the teacher has to be trained in all subjects, does not normally provide sufficient expertise in science teaching. Therefore, the improvement of training programmes for the primary teachers is also an important factor.
5. Since the existing teacher-training schools have very few facilities in terms of laboratory equipment, the right type of training in the methodology of science teaching becomes difficult. The teacher-training schools, therefore, need proper facilities and equipment.

Successes of the programme

1. The first important factor that has contributed to the success of the programme is the development of a climate for improving the tone of science education at school. This was achieved by the active collaboration of not only the curriculum makers and teachers but also of the scientists and research workers.
2. Some kind of uniformity in science content for the primary and middle school levels was achieved, wherein the basic concepts of science in terms of everyday life were particularly emphasized in selecting the content.
3. An effective State-level leadership has been developed, which is essential for this vast country with varying school systems, languages and expertise.
4. The content has been more interesting for the child by making it activity-based, and presenting it to the child in terms of his environment and day-to-day life.
5. The impact of the programme has been felt in the States. This is evident in the steps taken in several States to universalize the programme in all the primary and middle schools.

Other information and future plans

The pilot phase was limited to three years. The wider expansion phase normally lasts for another three years. So far as the universalization is concerned, there is no time limit as it has to depend on the availability of the State funds and resources.

The initiative of the project was from the Ministry of Education which invited the Unesco Planning Mission in 1963–64 to examine the state of science teaching in the schools throughout the country and give recommendations. The Indian Education Commission also recommended improvement on similar lines. The development of materials was the direct result of the recommendations of these missions. In the implementation of the project in the States, assistance has been forthcoming from UNICEF for equipment and training costs.

The Ministry of Education and Social Welfare, Government of India, provided the funding support for the developmental aspects of the project. Assistance in the implementation of the project is forthcoming from UNICEF. The assistance was in the following forms: (1) Funds for kits supplied to the schools; (2) 50 per cent of the cost of development of textbooks and other instructional material in the pilot phase; (3) 50 per cent of the cost of training the resource persons and teachers for the pilot and wider expansion phase. The balance was provided by the Government of India for the pilot phase and State Governments for the wider expansion phase.

The future plan of the project is to bring about universalization of the teaching of science on a compulsory basis in all schools for the first ten years of schooling. It is hoped to bring about curricular changes to integrate the environmental sciences, nutrition, health, and population education as integral parts of a science programme suited to the age-levels of the children.

The planners' aim is to make pupils understand science by doing experiments and for this to develop suitable inexpensive indigenous equipment and kits; to develop supplementary reading materials in science, suited to the age levels of children, and to motivate them to know many other aspects of science, which are not usually included in the textbooks; and to develop programmes for out-of-school science activities to supplement and enrich classroom learning and to foster the creative abilities of the pupils.

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INDONESIA

General background

Indonesia's education system aims to support the National development of a large population spread over a vast area: most of its problems stem from this fact. Indonesia is an archipelago of some three thousand islands scattered between the Indian and Pacific Oceans and has a total area of some 2.019.360 km^2. 94.2 per cent of the 130.000.000 people live on five main islands, Java being the most densely settled. The table shows how the population is distributed either on overcrowded Java or the underpopulated (in terms of land resources) Outer Islands.

Population Distribution

	Per cent of total population
1. Java	64.2
2. Sumatra	17.6
3. Sulawesi	7.2
4. Kalimantan (most of the island of Borneo)	4.4
5. Irian Jaya	0.8
6. Other islands	5.8
	100.00

For education, the other important demographic fact is the youthfulness of the population; more than 40 per cent of the population is under 25 years of age.

National education policy

The development of Indonesia for the period 1969–1995 is defined by the 1945 Constitution and the Outline of State Objectives (*Garis Besar Haluan Negara* = GBHN) and is being implemented through five five-year development plans (*Rencana Pembangunan Lima Tahun* = Repelita). The time period and main aim of each plan are:

1. Repelita I, 1969/70 – 1974/75, Development of Agriculture
2. Repelita II, 1974/75 – 1979/80, Development of Agriculture Processing Industry
3. Repelita III, 1979/80 – 1984/85, Development of Light Industry
4. Repelita IV, 1984/85 – 1989/90, Development of National Defence and Security
5. Repelita V, 1989/90 – Development of Heavy Industry.

The output of Education must be appropriate to the needs of the country. Educational reform is necessary if the younger generation is to be sufficiently trained to constitute a skilled workforce. The development of individuals and their human potential is also equally important. Since the beginning of Repelita I (1969), the Office of Education and Cultural Research and Development (*Badan Penelitian dan Pengembangan Pendidikan dan Kebudayaan* or BP3K) has been studying methods of educational reform to produce a system appropriate to national needs. Priority has been given to the training of scientists and technologists without, at the same time, restricting educational growth elsewhere.

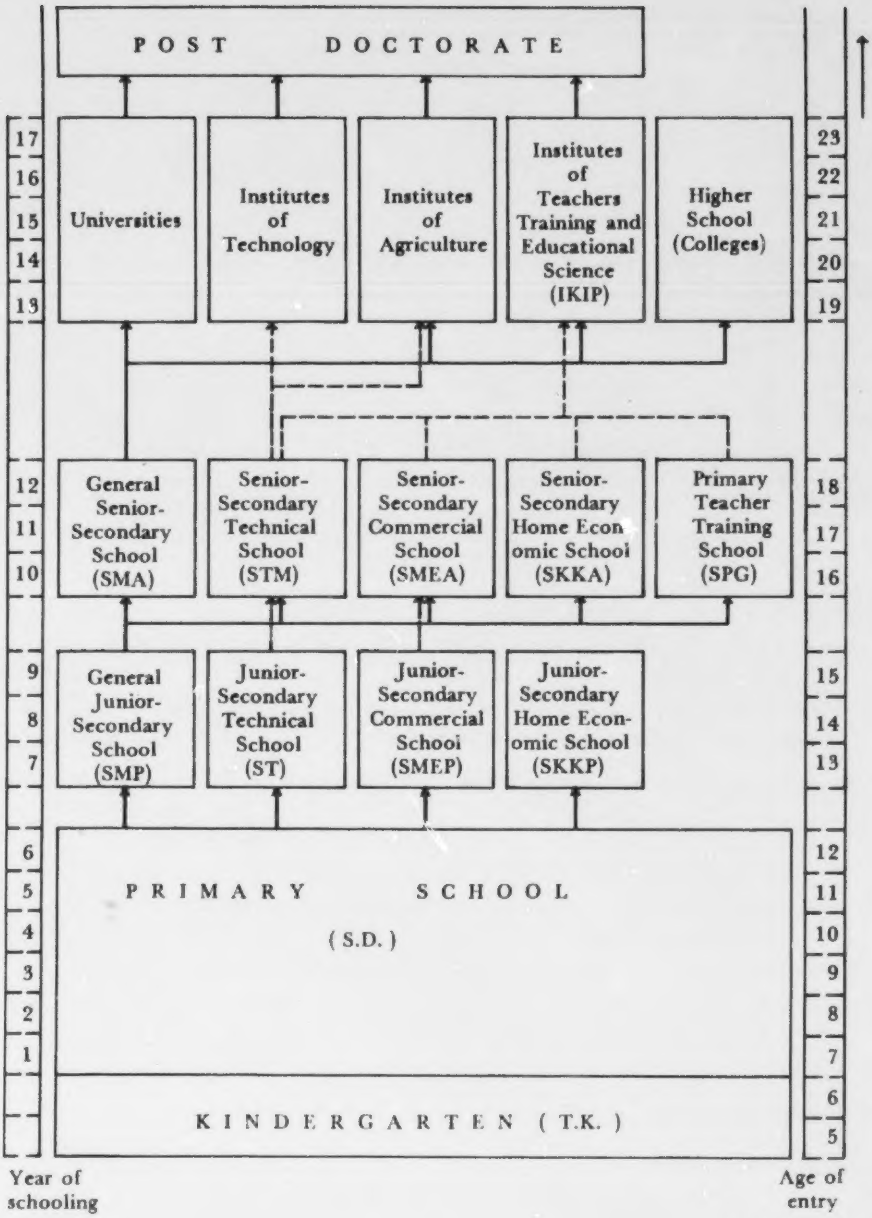
Present state of science education

The overall education structure is a 6+3+3 system with a unitary primary component and a diversified secondary component. (See diagram on page 50). The formal education system consists of: one- or two-year pre-school or kindergarten; six-year primary school; three-year junior-secondary school; three-year senior-secondary school.

Kindergarten. Kindergartens are provided for children aged between 4 and 6 years and in the first two years of school. Instruction is given in the local vernacular, and the method of teaching differs from one school to another. Kindergartens are managed and financed by private organizations or individuals, but the Government provides a curriculum as a guideline and establishes some institutions for the training of teachers. Commonly, kindergartens are established mainly in urban areas and very rarely in villages, although extensions are just beginning at village level.

Primary school. Primary school is provided for children aged between 7 and 12 years. A uniform curriculum is prescribed by the Minister of Education and Culture for all recognized schools, public, subsidized, aided and fully-private schools. Content is more or less the same throughout Indonesia, although provision is made for minor variations to suit local needs and conditions.

GENERAL STRUCTURE OF EDUCATION SYSTEM IN INDONESIA


POST DOCTORATE
Universities
Institutes of Technology
Institutes of Agriculture
Institutes of Teachers Training and Educational Science (IKIP)
Higher School (Colleges)
General Senior-Secondary School (SMA)
Senior-Secondary Technical School (STM)
Senior-Secondary Commercial School (SMEA)
Senior-Secondary Home Economic School (SKKA)
Primary Teacher Training School (SPG)
General Junior-Secondary School (SMP)
Junior-Secondary Technical School (ST)
Junior-Secondary Commercial School (SMEP)
Junior-Secondary Home Economic School (SKKP)
PRIMARY SCHOOL (S.D.)
KINDERGARTEN (T.K.)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
23
22
21
20
19
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16
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14
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12
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10
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8
7
6
5
Year of schooling
Age of entry

The possibility of Primary Education being made compulsory is very small since the growth of population is greater than that of the growth of the budget for education. Instruction is in the national language (Bahasa Indonesia), although the local vernacular may be used until the third year. Religious instruction is compulsory according to the student's own religion. At the end of the sixth year, pupils take their school examination and, if they pass, are awarded a *first* school certificate and may enter a junior-secondary school.

Junior-secondary school. Junior-secondary school is provided for children aged between 13 and 15 years. At this level, there are two different types of schools, general and vocational. Vocational junior-secondary education is provided in institutions such as: junior-secondary technical school, junior-secondary school of commerce, junior-secondary school of home economics.

Junior-secondary schools conduct their own examination at the end of the third year and those who pass receive a *second* certificate and may enter senior-secondary schools. The general junior-secondary school graduates may enter any of the different types of senior-secondary schools, while the graduates of vocational schools may only enter the corresponding senior-secondary school.

Senior-secondary school. Senior-secondary schooling is provided for children aged between 16 and 18 years. Again there are the two different kinds of schools at the level of senior-secondary education, general and vocational: general senior-secondary school, senior-secondary technical school, senior-secondary school of commerce, senior-secondary school of home economics, primary teacher training school, school for music and arts.

There are additional types of secondary schools not listed here because science or technology subjects are taught only in a limited way. Senior-secondary schools conduct their own examinations at the end of the third year and those who pass are awarded their *third* certificate and may proceed to higher studies at universities or other tertiary institutions. Only graduates from the general (i.e. non-vocational) stream may enter tertiary institutions, for graduates from vocational schools go directly into employment.

Promotion between classes is not automatic and students may repeat a year of study at any stage of primary and secondary education. Thus it is possible to find a range of student ages in each class.

Introduction to flow diagram and statistics

The diagram showing a flow of students through the system and statistics of the system should be read in conjunction with each other. Some salient points are:

1. The first main level of education covers the age-range 7 to 12;
2. The greatest number of students is concentrated in primary education. Thereafter numbers drop rapidly;
3. Primary schools are general in scope, while all post-primary education is specialized in a variety of institutions;
4. Specialized technical education begins as early as the seventh year of schooling (age 13 years);
5. The number of pupils at public schools is almost the same as the number at subsidized and fully-private schools.

The statistics of pupils, teachers, schools, and classes in which science is a main component (1975)

Kind of schools	No. of pupils	Total No. of teachers	No. of science / technology teachers	Total No. of schools	Total No. of classes	Average class size
Primary schools (SD)	14.700.000	450.827	*)	75.833	455.000	33
Junior-secondary						
– General junior-secondary schools (SMP)	595.911	26.600	2.937	1.417	14.939	39
– Junior-technical schools (ST)	148.864	10.203	5.000	565	5.291	27
Senior-secondary						
– General senior-secondary schools (SMA)	177.306	7.938	1.067	426	5.263	34
– Senior technical schools	74.475	4.781	3.142	144	2.278	30
– Primary teachers training schools (SPG)	45.702	2.589	150	204	1.348	31

*) No specialist teachers for science class; teachers teach all subjects except religion.

The planning mechanism for science education

Planning in science (and technology) education at the first and second levels is the responsibility of the Directorate General of Primary and Secondary Education. As the Directorates of Primary, General Secondary, Vocational and Technical Secondary, and Teacher Education each have a particular function and responsibility, responsibility for science education is divided among all four Directorates. The actions of each

Directorate are co-ordinated by the Directorate General of Primary and Secondary Education. Each Directorate has a planning staff working on curriculum, text-books, teachers' advancement and hardware needs. The staff also seeks the advice from universities, Institutes of Teacher Training (IKIP), foreign experts, industries and other relevant institutions and bodies.

Science education at the first and second levels

Science is taught throughout primary school with an emphasis on the introduction of elementary science in the first three years and environmental science and the science of living things in the next three years. The time allocated to science each week is:

- Grades I and II, two periods of 30 minutes each;
- Grade III, three periods of 40 minutes each;
- Grades IV, V and VI, four periods of 40 minutes each.

A new curriculum is being phased-in over three years (1976 to 1978). This uses the enquiry method in a unit system (*Prosedure Pengembangan Sistem Instruksionil*) with the emphasis on students' activities, in which the teacher acts as an organizer of learning activities and not just a source of information. The new curriculum is not radical but, rather, aims towards an evolutionary change in teachers' and pupils' attitudes, as well as content, and teaching and learning processes.

In general junior-secondary schools, science is compulsory at all levels and at all schools. It occupies four periods (two periods of physics and two periods of biology) at grades VII and VIII, and five periods (three periods of physics and two periods of biology) in grade IX, in which each period is 45 minutes in length. The curriculum is a continuation from primary school in method and organization.

In general senior-secondary schools, students have a choice between three majors; a mathematics and science major, a language major, and a social studies major. This choice is made after a common first semester in which science occupies seven periods of 45 minutes each per week.

In the science major the period allocation and balance between theory and practice is as follows: Grade I, 9 periods (6 theory and 3 practical); Grade II, 12 periods (9 theory and 3 practical); Grade III, 19 periods (12 theory and 7 practical). In the language major and social studies major, science is taught only to a limited extent.

In senior-secondary technical schools, science teaching is biased towards applied science and technology. The content is an introduction and a basis for a further training. The main science subject varies with the type of technical school.

Science (and technology) education in out-of-school education

There is no wide-range plan for non-formal education in science or technology. The largest and most effective non-formal education, however, takes place where children learn skills from parents and neighbours. Skills involving simple science and technology like ploughing, irrigation management, blacksmithing, carpentry and even shop management are all effectively learned in a very practical way within the family. The importance of this education cannot be stressed too much. It is also encouraging that the Department of Labour has established Industrial Job Training Centres which provide training courses of up-to six months' duration for secondary-school drop-outs who request specific vocational training.

Organization and instructional arrangements for science education

There have recently been a considerable number of changes and innovations in science (and technological) education. The processes by which these changes are fixed upon and implemented vary with the size and implication of the change. Major policy decisions and major programmes will require the authority of the Minister, while on a lower level, Directorates General and Directors have the authority to issue new policies and directives also. The procedure for drawing up the new policy or programmes consists of a series of consultative meetings which include not only relevant educational opinion, but representatives from trade, industry and employer groups. The widest possible consultation is sought so that the final document reflects a wide range of attitudes by the community. The implementation is made by the Minister or his representatives and is applied downward through the administrative system.

Materials and teachers

The Indonesian education system has, during the periods of Repelita I and II (i.e. since 1969) concentrated all available expertise, energy and resources into a major reform programme for the whole of primary and secondary education. The development of new curricula has been the focus of the renewal and reform. Associated with the completely new curricula through 12 grades of school has been the production of new textbooks for each grade in numbers large enough for every child in the system, as well as in-service training for every teacher in primary schools and teachers of the basic subjects, which include science in secondary schools.

The method of doing this has been to use special project teams, each of which has the responsibility for a particular part of the whole curriculum reform programme. Project teams are spread through the various Directorates. There are projects for the writing of new curricula, others for writing the textbooks and those for printing, publishing and distributing the books to all schools in the system. Thus, expertise is developed in specific task areas of the overall programme,and responsibility for the programme is more widely spread among people representing different Directorates and people with different skills.

Primary schools. Since science is taught throughout the 75,833 primary schools, the quantity of books involved is enormous. The new science syllabus began in 1976 when 2.8 million new texts and 280,000 teacher's guides were distributed for grade IV. In 1977, a further 2.8 million texts and 280,000 teacher's guides are being distributed as the new curriculum moves into grade V and, by the end of 1987, the programme will be completed with a further distribution of the same quantities of books for grade VI.

At the same time, teachers have to learn how to teach this new science curriculum. This training programme is likewise spread over three years and is co-ordinated with the arrival of textbooks in the schools. Thus, in 1976, all class teachers of grade IV were given extra training. There are 450,000 teachers to retrain and this is being done by 240 mobile teams of master teachers based in each *Kabupaten* (regency), usually at a Primary Teacher Training School. In each *Kecamatan* (sub-district), one school is nominated as a 'Central Primary School' in which teachers meet for the in-service training. 80,000 grade-IV teachers alone received in-service training in 1976. It is not only the teachers who have been retrained however. Their administrators at Provincial and *Kabupaten* (regency) levels, 332 and 3,252 respectively, must also know about the new curriculum, and so are retrained by the mobile teams. Future teachers also need to be informed and so laboratory equipment and laboratories are being supplied to 126 Primary Teacher Training Schools. Already 67 laboratories are under construction.

Secondary schools. The implementation of the new curricula in primary schools involves massive numbers of people and books. The number of secondary schools might be less, but the more advanced needs of secondary students complicate the programme by introducing the necessity for many new laboratories and the equipment to fill them. The task of retraining a specialist secondary teacher is also more complicated and needs longer periods of training. There is also a lack of trained secondary science teachers and opportunity is being taken to rectify this deficiency at the same time. The basic method of retraining is to send selected teachers from junior-and senior-secondary schools as well as IKIPs to the Science Teaching Centre in Bandung.

The three-month course covers physics, biology and chemistry. When these teachers return to their former work they have the responsibility to disseminate this new method of teaching among their colleagues. This is done on an organized basis at 11 regional 'upgrading' centres.

There is also an estimated shortfall of science teachers after 1976 over-and-above the 1,500 junior-secondary teachers under training. So between 1977 and 1979, 3,500 additional science teachers will be trained at Teachers' Colleges for junior high school teachers. This one-year crash programme is also a preliminary course which allows the teachers to continue studying at a later date in a nearby tertairy institution using this one-year course as credit towards a final degree. Senior-secondary teachers will base their upgrading courses on IKIP which is the level appropriate to their existing academic background. As in the primary school, there is also a great influx of books and equipment into schools. A variety of books is being distributed, both texts for the subjects of physics, biology, and earth and space science as well as reference books for school libraries. 204,000 and 56,000 such reference texts have gone into junior-and senior-secondary schools, respectively.

Classroom work covering the above three subjects is being served by the distribution of 1.9 million and 420,000 student texts at junior and senior levels, respectively, plus 20,000 teacher's guides for all secondary schools. Practical work is now being served with 240,000 student texts and 10,000 teacher's guides books.

The need for books is nation-wide, so reprints of 1,932,000 science texts are also going out to subsidized and fully private schools in the massive effort to raise the standard of science education. Science is also demanding at the secondary level in the provision of laboratory space. So, in 1974/75, 1,418 science laboratories were built in junior- and 852 in senior-secondary schools, with a further 65 for junior schools on the way.

These programmes represent a massive injection of money, equipment and new ideas into the existing education system. It is being carried out with a sense of urgency since the future development of the nation depends particularly on the number and quality of science students now passing through the schools.

Research and evaluation in science education

The Office of Education and Cultural Research and Development continuously works together with the appropriate Directorates doing research and evaluation. Research done in schools can be initiated by many bodies including BP3K, but this office has an overall responsibility for the adequate supervision and co-ordination of this research. The Primary

Education Development Centre (*Pusat Pengembangan Pendidikan Dasar = P3D*) in Jakarta is developing a new curriculum using 50 primary schools as experimental bases. These schools are distributed through West Java, Central Java and South Sumatra (Lampung).

Currently emerging trends

Curriculum developments. This is the major area of change in the Indonesian education system. The aim has been to apply the national ideals, objectives and development goals in educational terms so that the schools in a very direct way can serve the needs of a developing nation. It is thus possible to trace the elements of the national philosophy of *Pancasila** for example, through the various levels of curriculum definition right down to the operational skills which are to be developed by students in the classroom. Science, then, is being developed to serve the new generation of Indonesian youth and to increase the quality of their contribution to national development by following national goals.

So far, much of the attention has been devoted to increasing the number of teachers, books and laboratories as well as introducing the new curriculum. The next stage concerns teaching and learning methods. The curriculum has been designed so that it can be taught in a series of modular units. Each unit has its own objectives and own evaluation procedures which, through pre-testing and post-testing, can more accurately measure the progress of the student and emphasize that learning can fulfil very specific and quite general objectives simultaneously. No longer is the textbook the definition of what is to be learned. According to the new curriculum and the modular system, each learning task has as its objective the fulfilment of some aspect of the needs of the individual, society and nation.

Rationalization of school types. The system which Indonesia inherited from the Dutch was very fragmented and specialized at the secondary level with separate schools for technical, farming, home science and commercial education. The present trend is to consolidate or convert some vocational schools and technical schools into comprehensive schools.

Regional specialization. Certain schools reflect the local economy by training students for particular local industries; e.g., food processing in rural areas, metal trades in urban areas.

When resources are limited they should not be spread too thinly but rather concentrated in key geographical locations. The result is fewer schools with higher standards of equipment in strategic locations. Centres like the Technical Training Centres increase efficient use of resources by sharing equipment and skilled teachers with neighbouring schools.

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* *Pancasila:* the five principles of belief in God, nationality, humanity, people's sovereignty, and social justice.

One important consequence of the above points is higher morale among students and staff. The classification of goals, improvement of facilities and the increased likelihood of appropriate employment after training are making science education increasingly sought-after.

The main problem facing science education is the lack of a tradition of such education. There does not exist a pool of scientists from whom can be drawn experts in research, education and planning.

Other problems affect the whole of education and are not confined to science and technology education. The large number of schools is a result not only of the large population but also of the small unit-size of each school. The average junior-secondary school has only about 400 students. Yet classes are often large. Although some decisions are made at the *Kabupaten* and Provincial level, ultimate decision-making usually rests in Jakarta using information and recommendations passed up through the system. The number of communications between the centre and the large number of schools is therefore very high.

The problems of distributing information, books and equipment to thousands of schools distributed over many islands are not to be underestimated. The cost is not only high but time-lags must be built-in to planning programmes.

The ability of headmasters and teachers to understand and implement instruction from above depends very much on their training, skills, confidence and the extent to which they are aware of the overall context of particular changes.

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JAPAN

Present state of science education in Japan

Up to the end of 1945, a 'multi-track' school system was in force but, in 1947, the system was reformed into the so-called 'single-track' or 6–3–3–4 pattern.* The present system of Japan is shown in the diagram on page 61. Each of the school stages will be described in brief.

a) **Institutions of pre-school education.** The kindergarten aims at helping pre-school children to develop their minds and bodies by providing a sound educative environment for them. Kindergarten admits children of 3, 4 or 5 years of age. Three-year-olds are admitted to a three-year course, 4-year-olds to a two-year course and 5-year-olds to a one-year course. The majority of kindergartens are privately controlled.

Apart from kindergartens, there are day nurseries which also serve as pre-school educational institutions. While kindergartens are under the supervision of national and local *education* authorities, day nurseries are supervised by national and local *welfare* authorities.

b) **'Elementary' (primary) schools (six years).** All children who have reached the age of 6 are required to attend a six-year elementary school. The elementary school aims at giving children between the ages of 6 and 12 general education adapted to the state of their mental and physical development.

c) **Lower-secondary schools (three years).** All the children who have completed the elementary school course are required to go on to a three-year lower-secondary school. They must attend the school until the end of the school year during which they reach the age of 15. The lower-secondary school gives pupils between the ages of 12 and 15 general education based upon the education given in the elementary school.

d) **Upper-secondary school (three years).** Pupils who have completed the lower-secondary school course may go on to an upper-secondary school. The upper-secondary school courses are divided into these three types: full-time, part-time and correspondence. The full-time course lasts for three years, while the part-time and the correspondence courses take four years or more.

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* Primary school–lower secondary school–upper secondary school–university or college.

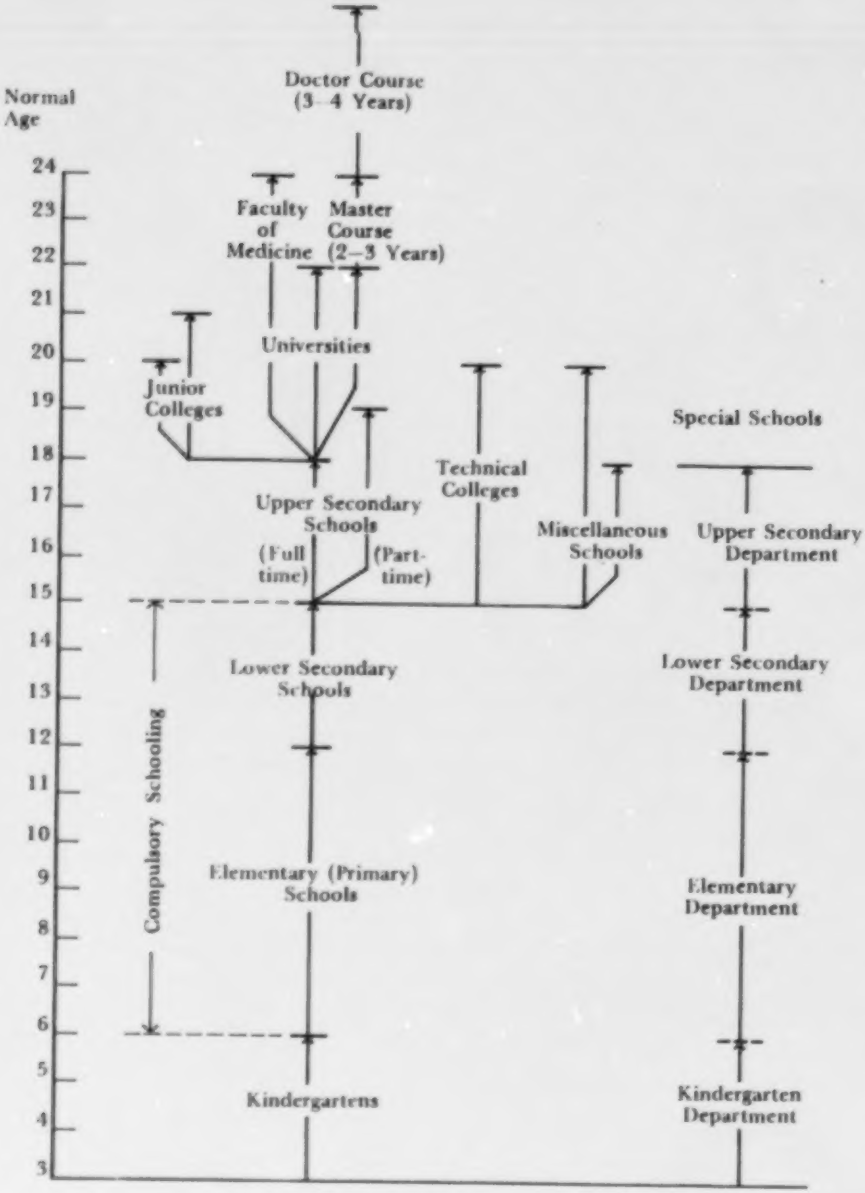
Upper-secondary school courses may also be classified into these two: the general and the specialized. The general course provides general education adapted to the needs of both those who wish to advance to higher education institutions and those who are going to seek employment but have not chosen any specific vocational area. The specialized course is intended to provide vocational or other specialized education for those who have chosen a specific vocational area for their career. Specialized courses are further classified into such categories as: technical, commercial, agricultural, fishery, domestic arts and science-mathematics.

e) **Institutions of higher education.** There are three types of institutions of higher education: university, junior college and technical college. Universities require for admission the completion of upper-secondary schooling or its equivalent and offer at least four-year courses leading to the bachelor's degree. A university may set up a graduate school offering advanced study in various fields and leading to the master's and doctor's degrees. (the diagram refers). The minimum period for a master's degree course is two years beyond the bachelor's degree; that of a doctor's degree course is five years. Junior colleges provide the upper-secondary school graduates with two- or three-year programmes in different fields of study. Junior colleges offer courses in the humanities, social sciences and domestic science. The majority of the students there are women. Technical colleges come into existence in 1962. They require for admission the completion of lower-secondary schooling and offer five-year programmes for the training of practical engineers or technicians. Those colleges offer courses in such fields as mechanical engineering, electric engineering, chemical engineering and civil engineering.

f) **Special schools.** Special schools aim at giving physically- or mentally-handicapped children special education adapted to their needs. There are schools for the blind, for the deaf and for the otherwise handicapped.

g) **Miscellaneous schools.** In addition to the above-mentioned educational institutions, there are a variety of educational establishments known as "miscellaneous schools". The greater majority of those schools are privately controlled and provide young people with vocational and practical courses in dressmaking, cooking, book-keeping, typing, automobile driving and repairing, computer techniques, electricity, TV-techniques and other possible techniques for vocations as well as 'general' education on specialized topics.

FIGURE 1. STRUCTURE OF EDUCATION SYSTEM IN JAPAN


Normal Age
24
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8
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5
4
3
Doctor Course (3–4 Years)
Faculty of Medicine
Master Course (2–3 Years)
Universities
Junior Colleges
Upper Secondary Schools
(Full time)
(Part-time)
Technical Colleges
Miscellaneous Schools
Special Schools
Upper Secondary Department
Lower Secondary Schools
Lower Secondary Department
Compulsory Schooling
Elementary (Primary) Schools
Elementary Department
Kindergartens
Kindergarten Department

The planning mechanism for science (and technology) education

The subjects to be offered and the standard of school hours per year for each subject in elementary and lower-secondary schools are prescribed in a Ministry of Education Ordinance entitled 'Enforcement Regulations for the School Education Law'. For upper-secondary schools, the same ordinance prescribes the kinds of subjects to be offered.

The basic framework of school curricula including the objectives and standard contents of teaching of different subjects is provided by the 'Official Curriculum' (or the Course of Study). The Official Curriculum is compiled by the Ministry of Education for each of three different school levels on the basis of the recommendation of the Curriculum Council, an advisory body to the Minister of Education, Science and Culture.

The latest revision of the Official Curriculum was carried out in July 1968 for elementary school, in April 1969 for lower-secondary school, and in October 1970 for upper-secondary school. The revised curricula were put into effect in April 1971 for elementary school, in April 1972 for lower-secondary school and in April 1973 for upper-secondary school.

Science education at the first level

The objective of primary school science is to acquaint children with nature: to make them understand the phenomena in the natural world logically and objectively in the process of observation and experiment and thus to increase their comprehension of nature, and to develop in children a scientific ability and attitude.

The contents of science education are 'Living Things and Their Environment', 'Matter and Energy' and 'The Earth and the Universe'. These three are co-related with each other and their teaching materials are carefully selected in due consideration of local needs and of pupils' interest. They are arranged in such a way as to make a study of basic subjects possible. The national standard of total number of class hours for elementary school are as follows: 68 for the first grade, 70 for the second grade, 105 for the third and fourth grades and 140 for the fifth and sixth grades.

Science education at the second level

a) The objective of lower-secondary school science is to develop the pupils' ability and attitude towards a scientific way of thinking and their interest in learning about nature. At the same time, lower-secondary school science aims at increasing the pupils' understanding of the relationship between nature and human life. Lower secondary school science consists of two integrated areas of study. The one covers teaching items organized from the standpoint of physical science and the other covers the items organized in such a way that living things and their environment may be studied from the standpoint of biological science (biology and earth science).

b) Upper-secondary school science aims at increasing students' interest in the phenomena of nature and having them learn about scientific ways of thinking. It seeks to stimulate their 'creative' ability as well. In the process of learning, students are led to understand the enquiry approach, and concepts, processes and environments of nature. The contents of upper-secondary school science are divided into nine subjects, as follows: Physics I and II, Chemistry I and II, Biology I and II, Earth Science I and II, and Basic Science (integrated science). The reason why most subjects are divided into I and II is that students' capability varies and a flexible curriculum of science is thereupon required.

In addition, there is an intensive Mathematics-and-Science course which is an academic one and has four science subjects: physics, chemistry, biology and earth science. Students are required to earn 19 or more credits in these.

Upper-secondary school students are required to study two or more from Physics I, Chemistry I, Biology I and Earth Science I and to earn 6 or more credits thereof.

Science (and technology) education in (regular) out-of-school programmes

The out-of-school education in science and technology for youth is offered by correspondence courses or miscellaneous schools of secondary-school and junior-college levels beside the abovementioned. There has been established a skill qualification system whereunder persons who have acquired skill through the course or at the school may be given a certificate. The system is in force with respect to 12 kinds of skill, including radio technique and reprography. The certificate is awarded by private organizations in compliance with the regulations set by Ministry of Education, Science and Culture.

Children's culture centres and science museums established and operated by the central government and local public bodies have been providing a place for young people for out-of-school activities in acquiring scientific knowledge through scientific experiments.

Organization and institutional arrangements for science (and technology) education

Prefectural or local educational centres or science and technology education centres have been offering the in-service training of teachers, and conducting research in curriculum development or science equipment preparation. An arrangement has been made for these centres to have their meetings in order to discuss the science and technology education of today and the future, and to exchange information on educational innovation.

As teachers' organizations, there exist many associations for primary school science teachers, lower-secondary school science teachers and upper-secondary school science teachers at national, regional and local levels. Membership in these associations is held not only by school teachers but also by supervisors of science education and university professors.

In order to encourage investigation in science education and the development of new experimentation apparatus, the Ministry of Education, Science and Culture has, since 1968, been giving these associations grants for special projects in science. Prior to this, a law called the Science Education Promotion Law was enacted in 1953, which opened the way for the Ministry to provide schools with experimentation facilities.

Instructional materials

Textbooks for science are prepared by private textbook publishers but are subject to the authorization of the Minister of Education, Science and Culture for use at schools. The textbooks to be used at schools are selected by local educational authorities and school teachers from among those authorized. Textbooks for primary and lower secondary schools are supplied for pupils free of charge. In addition, teachers' guidebooks or instruction books, which give examples of teaching methods, are prepared by the Ministry of Education, Science and Culture.

Standards for equipment have been set by the Science Education Promotion Law, as revised from time to time. Audio-visual aids are produced by private film producers and reviewed by the Ministry of Education, Science and Culture before they are used at school. Schools are aided financially by the Ministry in the purchase of such materials as overhead projectors, TV sets and film and slide projectors. In audio-visual education, there are approximately 900 audio-visual libraries throughout the country, which supply films on a loan basis for schools as teaching materials.

Training of teachers and other personnel for science education

a) Primary and secondary school teachers. Primary school teachers, who teach all subjects concerned, are trained in four-year courses of national universities or two-year courses of junior colleges. Teachers are required to have teaching certificates, of which there are first- and second-class categories. In order to obtain a first-class certificate, it is necessary to earn 124 credits at the four-year university course, which includes 36 or more in general education subjects, 16 or more in professional subjects and 32 or more in teaching subjects.

Secondary-school teachers teach subjects for which they are specialized according to discipline. They are also trained in four-year courses of national universities, or two-year courses of junior colleges. In order to obtain first-class teacher certification, it is necessary to earn 124 credits at the four-year university course, which include 36 or more in general education subjects and 40 or more in teaching subjects. This requirement is the same as that for the second-class certification of upper-secondary school teachers.

In an effort to keep up and improve the quality of teachers, the Ministry of Education, Science and Culture has been organizing three-day discussion meetings every year since 1971. The meetings are intended for selected members of study groups to study the matters that have been selected in every prefecture as being of common interest to all primary school teachers.

For lower-secondary school teachers, the Ministry has since 1972 been holding an official meeting every year for introducing the revised curricula to them. Seminars, too, have been organized by the Ministry since 1968 for the modernization of science education. The seminars aim at retraining one half of all science teachers for a period of five years. In the meantime, 31 universities throughout Japan have at present research laboratories for science education research and practice.

b) **Science supervisors.** For supervisors and advisers of science education in primary and secondary schools, a two-day seminar is held once a year in each district out of several prefectures. At the central level, the Ministry of Education, Science and Culture organizes a workshop once a year for supervisors of secondary school science education to study and discuss matters of practical importance to science education in school. A national seminar is another occasion offered by the Ministry for supervisors and members of science education centres; here the participants study innovations in science education and conduct research on a theme with experimentation. As a recent development may be cited an example of the establishment in 1972 of the Science Education Research Centre in the National Institute for Educational Research (NIER), which aims at investigating some topics for its own purposes and offers the opportunity of diffusing information on the research activities done by supervisors, staff members of prefectural science education centres and others.

Research in science (and technology) education

Since 1968, the Ministry of Education, Science and Culture has been making efforts to promote research projects in science education by means of the Ministry's grant as one of the grants for scientific research. In the past eight years, the grants have amounted to 1,040 million yen, and have covered 61 projects (1975) including curriculum development for science and mathematics education, environmental study, integrated sciences, teaching methods and learning processes with their evaluation. The projects are in science education, computer-applied instruction and other special topics such as the education of handicapped children. As a result of this promotional measure, various proposals have been made for the improvement of science education in primary and secondary schools. A report of nine years of research (1968–76) is to be published this year.

Meanwhile, NIER has for many years carried out fundamental investigation for the improvement of science education; the results may be found in its reports. At the same time, science education centres established and operated by local educational authorities have become more and more active in offering in-service training courses for teachers. The principal activities carried out by many of those centres are the planning and organizing of short courses for teachers to modernize science (and technology) education. The centres are aided by grants from the Ministry of Education, Science and Culture for the study of teaching methods that help to increase pupils' interest in science and technology, for technical guidance to inexperienced teachers in basic observation and experimental work, for the development of new methods of instruction and experiment, and for new teaching materials and equipment. The members of all the centres meet once a year to give reports on new developments and discuss the ways of solving the problems of common interest.

Emerging trends in science (and technology) education

Curriculum development. In the past nearly ten years, the need for innovation in science education has been keenly felt, particularly among scientists. In its effort to meet the need, the Ministry of Education, Science and Culture in 1968 launched a financial assistance programme of grants for research in curriculum development projects in science. A first report of findings of research work aided by the Ministry was published in 1973.

Development of teaching/learning materials. In addition to authorizing textbooks, preparing teachers' guidebooks and reviewing audio-visual aids, the Ministry of Education, Science and Culture prepares materials for seminars for teachers to make themselves familiar with newly designed curricula and their teaching methods in science and technology education. As new equipment and apparatus are developed, a greater effort has been made by the Ministry in raising the standards set by the Science Education Promotion Law, with a view to repleting the experimentation facilities of school for use by ordinary science classes and vocational classes.

New instructional methodologies. At present, a wide variety of audio-visual aids are being used in science and technology education. They are tape recorders, radio receivers, slide projectors and cameras, overhead projectors, films and cinecameras, television and video-tape projectors, teaching machines, analysers of the learning situation of pupils and, exceptionally, computer-assisted instruction equipment.

The Nihon Hoso Kyokai (NHK) or the Japan Broadcasting Corporation broadcasts the science and technology education programmes. The programmes are prepared by the Programme Council of NHK in accordance with the Official Government Curriculum. As one of the new instructional methodologies, a man-machine system of small scale has been introduced into a classroom, and is often used in science and technology education. How to make full use of multi-media in science and technology classrooms is indicated in the teachers' guidebook prepared by the Ministry of Education, Science and Culture.

Relationship between science education and technology education. In the technology education of lower-secondary school level, these five subjects are taught: drawing, woodwork, metal work, machine engineering, electrical engineering and horticulture. Pupils must acquire the basic scientific knowledge required for their understanding of engineering.

Upper-secondary school students must learn Japanese language, social studies, mathematics, science, health and physical education, fine arts and (for girls) homemaking. Students in the industrial course must study basic science (6 credits) or two of these subjects: physics I (3 credits), chemistry I (3 credits), biology I (3 credits), earth science (3 credits) as the science subjects. A close relationship between the science curriculum and technology curriculum has thus been established in the vocational courses of upper secondary school.

Utilization of community facilities as learning resources. Science and technology museums established and operated by the central government, and local (prefectural and municipal) government, communities, business establishments and private organizations offer educational programmes. In addition to museums of various kinds (338 in number), there exist children's culture centres (28) in cities and youth hostels,(4) in prefectures, which are active also in educational activities. The Science and Technology Agency of the Prime Minister's Office subsidizes government museums in the operation of mobile museums with a view to diffusing scientific knowledge throughout the country.

In the children's culture centres, which have been established as public welfare activities centres, there are science and technology rooms which are open free of charge to the children who wish to do experiments or to build scientific models. In addition, zoos and botanical gardens which are operated by the government, central or local, or local community organizations, have their programmes of ecological field surveys, geological surveys or collection of animals and plants which are accompanied by educational programmes.

Other resources are the broadcasting programmes of NHK and other private broadcasting establishments. The programmes are transmitted by radio and television for adults as well as for school pupils to contribute to the scientific and technological knowledge of all citizens. These learning resources are made wider use of as the number of households with radio and TV receiving sets increases.

Evaluation methods and procedures. There are three aims of evaluation in science (and technology) education:

1. Judgement of the process and achievement in pupils' learning;
2. To get the information for teachers' instruction, and
3. Necessity for administration.

The evaluation methods and procedures are closely related to the objectives of science education and technology education. Recently, many teachers have become aware of the usefulness of *behavioural objectives* of education. Evaluation methods and procedures are adjusted by the behavioural objectives of teachers' instruction. Some of the evaluation methods are as follows:

1. Evaluation in learning or instruction
    a) Evaluation by question and answer
    b) Evaluation by observation
    c) Evaluation by description (pupils' interest, attitude toward enquiry, skill in conducting experiments).
2. Evaluation by pupils' reports
3. Evaluation by paper tests as follows:
    a) Objective tests—true-false type, matching type, multiple-choice type, discrimination type, supply type and labelling type;
    b) Essay type tests—'unrestricted' and 'restricted' types.

4. Evaluation of performance tests
   a) Observation of pupils' behaviour
   b) Any products of pupils' activities in learning.
5. Curricular evaluation. In Japan today, it is felt important to broaden both formative and summative evaluation of curricula to include skills and attitudes as well as knowledge.

Trends in structural and institutional organization

Prefectural science education centres and the National Institute for Educational Research have been making a greater contribution to the improvement of science (and technology) education. These centres are in a position to formulate a co-ordinated plan encompassing the schools of primary, lower- and upper-secondary stages, and to make a harmonious development of different elements of science education and technology education such as: the science curriculum for in-service training of teachers, science education research, evaluation and science equipment production.

Identification of problems

Science and technology education have developed keeping pace with the economic growth and the progress of natural sciences and technologies in the past 20 years. In April 1975, 92 per cent of total lower-secondary school graduates went on to upper-secondary schools or technical colleges. Approximately one-third of the upper-secondary schools offer both general and vocational courses, more than one-third of them a general course only and the balance specialized courses only. Those schools supply technicians and lower engineers to the industrial society of Japan.

Recently, technology education in Japan has come to a virtual standstill. One of the reasons is that many lower-secondary school graduates are inclined to go on to the general course of upper-secondary schools. Such a trend seems to increase the difficulty in offering sufficient technology education to meet the vocational requirements. On the other hand, the general course of upper-secondary school, too, is faced with the pressure of the preparation for the entrance examination to university or college. The preparation for the entrance examination affects the curriculum of upper-secondary school in many phases.

Future plans for science education

The upper secondary schools in Japan have shown continuous improvement as an educational institution providing higher general education and vocational education since the new school system came into existence in 1948. Their expansion can be seen clearly in the remarkable increase in the upper-secondary school enrolment. The ratio of those who proceeded to upper-secondary schools to the total number of lower-secondary school graduates was 57 per cent in 1960. This increased to 82 per cent in 1970 and further to 92 per cent in 1975.

Under the circumstances, the Curriculum Council was set up in the Ministry of Education, Science and Culture in 1973, which, upon request by the Minister, studied many problems in relation to curricula. The Council made its recommendations to the Minister, which include the following items, upon which the Official Curriculum is being revised:

1. Flexibility of curriculum organization;
2. Careful selection of the basic or the fundamental contents, and establishment of continuity in the curricula for primary and secondary schools;
3. Building up of well-balanced personality in pupils; and
4. Helping pupils to lead a richer school life.

Bulletin of the Unesco Regional Office
for Education in Asia
Number 18, June 1977

REPUBLIC OF KOREA

Present state of science education

The basic structure of the educational system is based on a 6+3+3+4 pattern from elementary (primary) school through to college graduation. The Constitution of the Republic provides free and compulsory primary education for every child in the 6–11 age group. In recent years there has been an increased enrolment in middle schools.

Since 1969, children who have completed primary school have been allocated to middle schools in their districts by a 'lottery' system. After three years at middle school, students must take an entrance examination for 'high school'. Since 1974 the entrance examinations have been conducted on a trial basis by the Provincial and Special City Boards rather than by the high schools themselves.

Upon graduation from high school, students must take entrance tests administered by the Ministry of Education in order to qualify for entrance to Universities and Colleges. Students apply to the institutions of their choice. The individual Universities and Colleges then conduct their own admission tests.

At middle- and high-school stages, 43 per cent of the schools are private. Approximately 50 schools that cater for children who are physically or mentally handicapped are also run by private foundations.

Planning mechanisms

Decisions concerning objectives, curriculum content and teaching methods are made by the Textbook Compilation Bureau within the Ministry of Education. Curriculum committees are established for each subject area. The committees are made up of 30 members drawn from colleges and schools, and from the staff of the Textbook Compilation Bureau.

Each year, the Ministry of Education designates some schools as Experimental Schools. These have a special role in studying and offering suggestions for improvement concerning particular topics that are assigned to them. During the period of their studies the teachers are assisted by staff members of teacher training institutions, by supervisors, by textbook specialists and by the staff of the Science Education Project Office. The Experimental Schools file reports on their work which are then carefully examined with a view to incorporating suggestions in subsequent curriculum revision.

When a new curriculum is prepared, it is thoroughly examined by the members of the relevant curriculum committee and finally it is officially released for implementation on a country-wide basis by the Ministry of Education.

Science education at the first and second levels

The objectives of Science Education for students at all levels are clearly stated in the Law for the Promotion of Science Education which was enacted in 1967. Its basic objective is to develop an understanding of:

1. The concepts and principles used to describe the universe and phenomena occurring within it;
2. The nature of the mental and manual activities by which scientific knowledge is revised, expanded and deepened;
3. The ways in which both the processes and the concepts of science are applied either in further research or in solving practical problems;
4. The ways in which the scientific method can be used to tackle problems in other areas in an objective manner.

It is considered very important that all citizens develop scientific skills and attitudes so that they can apply science in their daily lives and build a firm foundation for the development of technology.

In 1972 the Ministry of Education issued a further series of directives concerning science education; namely:

1. To revise the science curriculum to emphasize scientific concepts and processes;
2. To devise methods of making the learning of science more meaningful by introducing more experimental work;
3. To provide an atmosphere that would stimulate the quality of science teaching by fostering the exchange of ideas at international and domestic levels;
4. To make efforts to achieve the above goals by extending the Unesco/Unicef-Assisted Korean Science Education Project to include the production of equipment for the teaching of science.

During the period 1972–1975, fifteen Science Education Centres were established at National Colleges of Education (four) and Junior Teachers' Colleges (11). They received equipment supplied by Unicef.

The work of the Science Education Centres includes the following:

1. Conducting research and curriculum development projects;
2. Providing advisory services for experimental schools;
3. Displaying and lending science education materials;
4. Strengthening in-service and pre-service teacher training courses;
5. Providing consultant services for classroom teachers.

Another group of institutions called Student Science Centres is being established throughout the Republic of Korea. These Centres co-operate with the Science Education Centres to bring about improvements in the teaching/learning situation in the classroom. There will be a Student Science Centre in each of the nine provincial capitals and the two special cities of Seoul and Pusan. They constitute clear evidence of the importance attached to the teaching of science and technology. Their functions can be summarized as follows:

1. Displaying exhibits and working models that illustrate aspects of science and technology;
2. Acting as centres for supplementary science laboratory experiences for children;
3. Acting as community centres for in-service teacher training activities;
4. Stimulating the spread of scientific information and attitudes to all sections of the community in order to facilitate the development of local resources and industry.

In order to facilitate the development of science (and technology) teaching, three sections, the Science Education, Technical Education and Vocational Education Sections have been established under the umbrella of the Science Education Bureau. The Technical Education Section deals with matters relating to Engineering–Chemical, Mechanical, Electrical. The Vocational Education Section serves the schools and colleges that are especially concerned with Agriculture, Fisheries and Nursing, and with commercial courses. The Science Education Section Administers programmes connected with the pure sciences up to secondary and Junior Teachers' College stages.

When any Section decides on a particular plan of action, experimental schools are usually utilized to conduct trials. The Science Education Bureau has to co-ordinate its activities with those of the Textbook Compilation Bureau, the Supervisory Bureau, and Colleges concerned with teacher education.

Instructional materials development

After textbooks have been written by members of the staff of the Textbook Compilation Bureau, the texts are printed by the Government Printing Office which then handles their distribution. These texts are purchased by the students. There is provision for free texts to be given to primary-school children who have financial difficulties.

In 1972, the Science Equipment Development Centre was founded for the purpose of producing science equipment required for teaching in schools. The building was erected by the Korean Teachers' Mutual Fund which manages the Centre. The initial production equipment was supplied by Unicef and technical advisory services are provided by Unesco. It is expected that materials produced in the Centre will appear in classrooms from the beginning of 1976.

In 1972/73 the Korean Educational Development Institute was inaugurated. The Institute is primarily responsible for carrying out and co-ordinating educational research and development projects in Korean primary and secondary schools. The major areas of concern of KEDI at the present time are:

1. The development of teachers' guides or manuals and student workbooks to complement the prescribed textbooks;
2. The development of a new model of an instructional system which will direct more attention to the needs of individual children;
3. The preparation of a programme utilizing instructional television so that differences in quality between rural and urban schools will be reduced.

The training of teachers

There are three distinct types of institutions which are concerned with teacher education in the Republic of Korea. One type of institution is the Junior Teachers' College, (JTC), of which there are 16. These provide two-year courses to students who have already graduated from high school and who will teach in elementary (primary) schools. The JTCs require 81–87 credit-hours which include six weeks of practice-teaching. There is a general requirement of 25–29 credit hours for Korean language, History, Natural Science and other basic subjects. Another 50 credit-hours are devoted to professional course requirements which include methodology courses in Science, Mathematics and Social Studies. One of the nine basic subject areas is selected as a major and 6–8 credit-hours are allocated to it. To take a particular case, at Inchon Junior Teachers' College, a student who selects science as his major will have five credits for science as a general requirement, four credits for the method course in science teaching and eight credits for the science elective, making a total of 17 credits in science. After the completion of the 81–87 credit-hour course, students receive a teachers' certificate enabling them to teach in elementary schools.

The second type of teacher-training institution is the National College of Education, of which there are eight. These prepare students to teach at the second level. The courses are four-year, 160-credit-hour courses, and consist of an 80-credit-hour general requirement and 80 credit-hours of electives.

The third type of institution is the Technical Colleges attached to Universities. Technical and vocational teacher training is offered at these colleges.

In-service courses. Each summer since 1971 there have been in-service courses for teachers of science and mathematics. The courses have been conducted at the Science Education Centres already mentioned. In 1975 there were 62 classes of 40 science teachers and 50 classes of 50 mathematics teachers retrained during 10-day courses at the first level. At the middle-school stage there were 15 classes of 40 science teachers and eight classes of 50 mathematics teachers enrolled for courses, each lasting 30 days.

Current trends in science education

There is a movement for the improvement of teaching in science (and vocational) subjects. This extends through all levels to the movement for revitalizing reform and the 'New Village' movements. These programmes have as their objectives:

1. Improvement of the quality of literacy of the citizens, with emphasis on the value of education; and
2. Renovation of science (and technical) education.

Current trends can be summarized as follows:

1. Curriculum review and research which is carried out in two ways by teacher-training colleges:
   a) Adaptation of materials obtained from abroad;
   b) Local development of new materials according to special resources and needs;
2. Continuous appraisal and revision of teacher education programmes;
3. The Korean Educational Development Institute (KEDI) is involved in examining and revitalizing Korean education;

4. The Science Equipment Development Centre is designing and producing science equipment;
5. Student Science Centres in each province are seeking ways to co-ordinate all of the educational activities in their respective areas.

Knowing the importance of science and technology education, the Ministry of Education has made an effort to improve its policies and its supervision in these areas. The Ordinance of Science Education Promotion was put into force in March 1967 as a legal basis for implementing all of the necessary steps for introducing changes in science education. The Enforcement Regulations concerned with science education were introduced in 1969. The Science Education Project has been in operation since 1968.

Identification of problems

A major problem is that, in both pre-service and in-service teacher education, the predominant mode of instruction is the lecture. There is a great need to encourage the use of a wide range of teaching techniques and to show how these can be integrated to provide more efficient instruction. This problem is being tackled at workshops, seminars and in-service courses but progress is slow. The large size of classes in Korean schools (60–80 pupils) is a continuing impediment to progressive teaching methods.

A second problem is that teachers' certificates are issued almost automatically to all students who complete the training courses. There is no adequate way to encourage quality among teachers.

In the third place, laboratory and library facilities are quite inadequate. Further, education is a co-operative human enterprise: one of the crucial factors is to co-ordinate the activities of all teaching and research institutions. Our administrators are well aware of the problems and are trying to solve them collectively.

Future plans

An emphasis on science and technology education will continue. Effective ways to encourage improvement will be actively sought. The two principal trends are:

1. To foster the utilization of scientific methods in the daily life of the people; and
2. To strengthen vocational skills of the work force.

These objectives are to be reached through both in-school and out-of-school programmes. The Ministry of Education is paying particular attention to the projects listed below.

1. Strong support for research and developmental studies in curriculum materials and teaching techniques at the National Colleges of Education, the Junior Teachers' Colleges and the Science Education Centres;
2. Re-examination of the programmes used for both pre-service and in-service teacher education;
3. Trial studies on the utilization of Student Science Centres;
4. Encouragement of research and development studies at the Korean Education Development Institute;
5. Enhancement of science equipment production at the Science Equipment Development Centre;
6. Implementation of innovative programmes generated through the assistance of Unesco and Unicef.

A science education project in the Republic of Korea

The project was initiated by an agreement made between the Korean Government, the United Nations Educational, Scientific and Cultural Organization (Unesco), and the United Nations Children's Fund (Unicef) in 1968. The goal of the project has been to evolve an indigenous science education programme for primary and secondary schools which can be ultimately supported by Korean resources.

To achieve the above goal both the Project Office and the Ministry of Education played a central role in the beginning–in the dissemination of new ideas and materials through seminars and workshops and teacher education institutions. Beginning in 1972, Science Education Centres were established to function as catalysts to make constructive changes in elementary and secondary school science teaching in their respective areas.

Objectives of the project are as follows:

1. Development of new curriculum materials and new teaching methods, relevant research and implementation;
2. Pre-service and in-service training;
3. Provision of new equipment and materials for the teaching of science;
4. Development and improvement of communication among science teaching;

To achieve the objectives, a plan of activities has been established with the principles given below.

1. The Science Education Centre system should be expanded to enable it to fulfil its role as a central agency for research and development. These centres should serve as centres for research by prominent professors and educators on teaching methods, science and mathematics curricula and the development of experimental apparatus.
2. In order to implement experimental teaching, appropriate equipment should be supplied to schools and teacher training institutions.
3. A Science and Mathematics Education Newsletter is to be published to serve as a forum for the exchange of ideas among participants in the science education movement.
4. Seminars and workshops should be held to discuss science and mathematics curricula, teaching methods, teacher training, evaluation and supervision.

To disseminate new science curricula and stimulate regional research efforts, one experimental school in each of science and mathematics has been appointed by the Ministry of Education, in each of the provinces, at the first and second levels since 1972. These schools have been supported by the Science Education Centres in the provinces and the Project Office. These studies have had a great deal of influence on the science and mathematics curriculum revision which has been taking place since 1973. New texts for both primary and secondary schools have been produced.

In the light of experience gained during the past years, the project activities have been modified in several directions to evolve an indigenous science programme. Equipment and materials supplied to the teacher-training institutions have been used effectively for pre-service and in-service teacher training. Workshops and research programmes for teacher educators, and in-service training for science teachers gave opportunities for innovation in science and mathematics teaching and curricula.

Formerly education in our country meant listening to the teacher and reading textbooks. Teachers were reluctant to adjust to changes in society. In general there was a paucity of science equipment in elementary and secondary schools and too many children in a classroom. Owing to the government and the project inputs and their joint efforts to overcome the difficulties, a great improvement has been achieved in increasing the skills of teachers. The availability of equipment in teacher training institutes and in school classrooms is also greater, and the communication of new ideas is more effective.

The money made available by Unicef and by the government has been used for equipment purchase for the 15 Junior Teachers' Colleges and for the in-service training of 25,000 teachers, as well as for 37 studies on curriculum development and research carried out by science educators.

The project has contributed a great deal in introducing new science and in disseminating new ideas about teaching science among teacher educators and teachers. To form the cornerstone for improving science teaching, the Science Education Centres have been established to conduct curriculum development and research. The centres play central roles as resource centres in the provinces. Each centre cannot penetrate completely into local levels, however, because of insufficient staff to cover the many schools in each province. Therefore a new idea—a 'Decentralized Resource Centre'—is proposed for future operation of the project.

It is intended that each subdivision within the provinces, the *gun,* will have a Decentralized Resource Centre. These Centres will act as channels of communication between the Science Education Centres in the Colleges and the rural schools. The teachers at the Decentralized Resource Centres will be asked to monitor the needs and the weaknesses as well as the local resources and the strong points of science teaching in their area. Then, together with Science Education Centre staff, seminars can be arranged according to local requirements. This scheme is now being tried on a pilot basis. In the long term it may be possible to co-ordinate this programme with the activities of the Korean Educational Development Institute which is carrying out a research programme and is also planning instructional television and radio programmes.

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MALAYSIA

Background

The Federation of Malaysia consists of 13 States in Peninsular Malaysia, Sabah and Sarawak. The East Malaysian States of Sabah and Sarawak have autonomy over their education policies but they are slowly moving towards the education system of Peninsular Malaysia. The Ministry of Education is responsible for the implementation of educational policies and the administration of the entire educational system. At the State level, the State Director of Education is the executive head through whom the Ministry operates.

Every child is entitled to nine years of education (Grades I to IX). Promotion from one grade to another is automatic during these years.

1. **Primary education**: Standards 1–6 (Grades I–VI)
   Age: 6+ to 11+
   Primary education is free and universal but not compulsory.
2. **Lower-secondary education**: Forms I–III (Grades VII–IX)
   Ages: 12+ to 14+
   Education is comprehensive in nature. Among other subjects pupils are taught one of the pre-vocational electives, namely, Industrial Arts, Home Science, Agricultural Science or Commercial Studies.
3. **Upper-secondary education**: Forms IV–V (Grades X–XI)
   Ages: 15+ to 16+
   Pupils who complete their lower-secondary education satisfactorily qualify for upper secondary education in Secondary Schools (Arts, Science and Commercial streams), fully residential schools (Science and Commercial), Technical Schools and Vocational Schools.
4. **Pre-university classes**: Form VI (Grades XII and XIII)
   Ages: 17+ to 18+
   Pupils who perform creditably at upper-secondary level (excluding Vocational Schools) are selected for a further two-year period in Arts, Science or Technical streams.

The medium of instruction in Primary School is Bahasa Malaysia, Chinese or Tamil. The medium in secondary schools is mainly Bahasa Malaysia or English. Between 1970 and 1980 all the English-medium schools will convert to Bahasa-Malaysia-medium schools.

Some pre-school or kindergarten education is available, organized by private individuals or bodies and government agencies. There are special schools and integrated classes for the blind, deaf, spastic and retarded children. In addition to the normal school system, the Ministry of Education also operates further educational classes at various levels.

The Ministry of Education prescribes the courses of study and the framework for the curricula. Extramural activities are compulsory and include club activities, literary activities, athletics and games, scouting, police and army cadet corps and other leadership and training activities.

The planning mechanism for science education

In general the school curricula and in particular the science and technology education are planned by the Central Curriculum Committee which is chaired by the Director-General of the Ministry of Education and the members are the heads of various professional divisions of the Ministry of Education. Subjects of national importance and those that require financial commitments are referred to the Educational Planning Committee, which is chaired by the Minister of Education.

The Secretariat of the Central Curriculum Committee is the Curriculum Development Centre. This Centre has established Mathematics and Science Committees to advise on matters pertaining to science and mathematics education.

Science education at the first and second levels

Science is a compulsory subject from Grades I through VI—that is, for the whole of the first level—and also from Grades VII through IX, the first three years of the second level.

For the first level, science lessons are taught in organized classes that follow regular timetables. The lessons are determined by a set syllabus, the chief characteristic of which is to present science as a unitary whole. Guide-books produced by the Ministry of Education are available to teachers to help them to understand the objectives of each unit of the syllabus, interpret the syllabus content, adopt suitable teaching approaches, carry out relevant demonstration experiments, direct pupils' activities, and assess pupils' progress.

Externally-set assessment tests are annually applied to pupils who are completing either Grade III or Grade V. The results of such tests are made available to teachers who use them for diagnostic purposes.

From Grades VII through IX, science is taught as Integrated Science—a combined study of physics, chemistry and biology which follows logical sequences of concept development. Pupils' worksheets are employed to encourage many practical exercises. An enquiry approach to learning is stressed in the course.

A fixed syllabus and teachers' guide-notes are prepared by the Ministry of Education for use by teachers who teach the course in organized classes following regular timetables. On completing this Integrated Science course at Grade IX, pupils sit for an external examination to qualify for the Lower Certificate of Education. This examination employs 'objective-type' question papers.

For Grades X and XI, pupils have a choice of science subjects from among the following:

a) General Science, Malaysian Syllabus or General Science, Cambridge Syllabus;
b) Additional General Science, Cambridge Syllabus;
c) Biology, Malaysian Syllabus, or Biology, Cambridge Syllabus;
d) Chemistry, Malaysian Syllabus, or Chemistry, Cambridge Syllabus;
e) Physics, Malaysian Syllabus, or Physics, Cambridge Syllabus.

In general, the Cambridge syllabuses allow the teachers freedom to organize and teach their own courses while the Malaysian syllabuses provide detailed guide-books for teachers in an attempt to broaden teaching characteristics. The Cambridge syllabuses have so far given rise to the more traditional lecture styles of teaching. On the other hand the Malaysian syllabuses developed since 1969 aim for a wider spread of outcomes through the enquiry approach and employing many practical exercises. They are adapted from the Nuffield "O" level sciences of the United Kingdom.

When pupils complete these courses at Grade XI, they sit for an external examination to qualify for the Malaysian Certificate of Education. There are separate examination papers for each kind of syllabus. Those for the Malaysian syllabuses are being constructed so as to test a wide range of cognitive skills.

Grades XII and XIII are the last two years of the second level, and are described as post-secondary or pre-university. Science courses are available in the subjects of Biology, Botany, Chemistry, Physical Science, Physics, and Zoology. The courses are all still very traditional in character, following fixed curricula in organized classes. The syllabuses are set by Cambridge, which conducts an external examination for pupils who complete Grade XIII to qualify for the Higher School Certificate.

Science education in out-of-school programmes

Organization of out-of-school programmes in science education is carried out by both the Ministry of Education and private enterprises for over-age students, school drop-outs and others who could not be given places in the existing formal school system.

The Ministry of Education programme is conducted in the form of Further Education Classes. These classes make use of existing school facilities and are conducted after the normal school hours, mainly in the evening. The science courses for these classes are identical to those taught in the formal school programmes.

Private schools exist in various forms and sizes, and have varying degrees of success in the provision of out-of-school science education. These private schools usually follow the same courses as those in formal school programmes. The preparation of pupils to qualify for external examination certificates is the chief intention of such schools.

Organizational arrangements for science education

Policy decisions and directions are given by the Central Curriculum Committee of the Ministry of Education. The preparation of curricula and their evaluation is the responsibility of the Curriculum Development Centre, while the Schools Division is responsible for its implementation.

At the State level there are State Science Supervisors who advise the State Director of Education in executing the policies of the Ministry of Education. Out-of-school activities in science are organized by the Schools Division of the Ministry of Education.

Development of instructional materials

The Development Section of the Finance Division of the Ministry of Education is responsible for building schools, workshops and laboratories as required, as well as extensions to the existing facilities. Initially, the basic equipment and apparatus are supplied to the new workshops and laboratories by the Supply Section of the Finance Division. The Finance Division also gives grants to the schools through State Education Departments for annual recurrent expenditure. Initially, the supply is through the Ministry of Education and the schools use their grants to purchase additional materials from the open market.

The Textbook Bureau, Ministry of Education, evaluates textbooks published locally and prescribes them for use in schools. In some cases, where a new syllabus has been introduced by the Ministry, the Ministry has also produced textbooks and Teachers' Guides. These books have been prepared by groups of practising teachers. The *Dewan Bahasa dan Pustaka* (Language and Literacy Agency) of the Ministry of Education publishes textbooks written locally as well as translations of foreign texts.

Generally, pupils purchase their own textbooks. From 1975, the Ministry has introduced a national loan scheme through which the poor pupils may borrow the required texts.

The Educational Media Service, Ministry of Education, has produced charts, slides, posters and film strips for use in schools and ETV regularly screens programmes in science at both the first and second levels.

Training of teachers and other educational personnel

The minimum academic qualification required for training as a teacher is the Malaysian Certificate of Education, awarded after 11 years of satisfactory educational achievement. The training is given at two levels: university level and college level.

At the Teachers' Colleges, teachers are trained for two years. These teachers normally teach science, commerce, industrial arts and home science at the primary or lower-secondary stages.

Generally, the universities cater for the needs of the upper-secondary. The universities offer courses at either Diploma or Degree levels. Science and Agricultural teachers with degrees normally undergo a one-year course for the Diploma or Certificate of Education. Diploma courses are offered in science, agriculture and technical subjects. The science courses are integrated with education.

Laboratory assistants/attendants are given training on the job. From time to time, in-service courses are conducted for them.

The Ministry also regularly conducts intensive in-service courses for teachers in order to improve the quality of teaching and to increase their knowledge in new developments and techniques.

Research and evaluation in science education

There is a continuous evaluation of the science curricula in the schools. This evaluation is generally done through visits to schools, questionnaires and analysis of the examination and assessment tests conducted at the national level.

Pure research is conducted by the Universities, but rather few of the findings are available at present.

Current trends and future plans

The new programmes in science and mathematics, which were developed in 1969, are now in the process of being put into practice in schools all over the country. These programmes are by no means finalized yet. They are being continually revised in accordance with knowledge obtained through their subsequent development and implementation.

The trend for the near future is not to attempt any major innovation in science and mathematics curricula but to consolidate the work that remains to be done in evaluation and revision. For this purpose, the Ministry has established a Curriculum Development Centre which was established with a World Bank Loan. This centre will soon have its own buildings and facilities for further development of science curricula, resource materials, evaluation programmes and re-orientation of teachers. The Curriculum Development Centre is currently engaged in research for the present science curricula.

The complete conversion to S.I. units in all science and mathematics courses is being carried out in line with the Metrication programme of the country, which has set the year 1981 as the target date for full metrication in all matters of weights and measures.

Problems in the development of science education

The development of science education has been taking place against a background where, in schools, large classes are common. The introduction of free primary education and automatic promotion from Grade I through Grade IX have together swelled the enrolment, particularly at the first level. The curriculum is a fixed one and is common to all schools. External examinations are conducted for all the science courses. The administration is largely not scientifically literate and teachers generally do not belong to any professional science teacher associations.

There is still a shortage of people with experience in curriculum development and renewal. The science and mathematics programmes initiated since 1969 have been heavily dependent on the services and expertise of consultants and experts from abroad, notably the United Kingdom. Hence there has been the necessity of a great deal more conscious effort on the part of the curriculum developers to make the courses relevant to local conditions.

The new science and mathematics courses contain much content matter that is new and unfamiliar to many science and mathematics teachers. To introduce the new courses in their schools, teachers not only have to learn new content matter and how to use unfamiliar teaching resources, they are also required to employ a much wider range of skills in their teaching than before. More of their time is also required for planning and organizing the practical work that these practical courses demand.

The country has all along been experiencing a shortage of qualified science teachers. In many schools, science courses, particularly in the lower grades, are taught by unqualified or underqualified teachers who cannot be expected to learn and carry out new procedures to try and attain course objectives. Many schools are also using the services of contract or volunteer teachers from foreign countries.

Generally speaking, teachers in Malaysia employ the lecture style of teaching. They vary considerably too in capabilities. Few science teachers have the necessary experience and knowledge to really be able to integrate well the separate areas of science that they teach as "integrated" science in the lower grades. There has been, and still is, resistance to change from traditional to more modern ways of teaching. There exist too few experts who are conversant with current learning ideas and practices to be able to influence the large number of teachers teaching science. Although the Ministry of Education conducts in-service reorientation workshops for teachers, financial constraints limit the number of training places available annually.

Since the new courses require much more practical activity for pupils and for smaller groups of pupils, it is necessary to provide for new apparatus as well as more items of apparatus. Local design and production of science equipment is still very limited. Equipment required has been bought from overseas sources at quite high cost. This has stretched existing resources, funds, and laboratory space to their limits.

The new science courses have also made necessary new testing procedures. Teachers who can construct suitable test items to include testing for higher abilities are indeed few. The Ministry of Education is now providing training in test construction but only to a limited number of science teachers each time.

SCIENCE EDUCATION PROJECTS IN MALAYSIA

Integrated Science Project for Lower-Secondary Schools

In 1968, the Ministry of Education began to re-examine and modify its primary and lower- and upper-secondary science and mathematics curricula. Science courses had previously been taught in the usual traditional ways following set syllabuses as laid down by the Cambridge Local Examination Syndicate. There was need to introduce more modern approaches to be able to attain a wider range of learning outcomes.

Objectives of the project

1. Overall project purpose: to improve science teaching and learning in the lower-secondary schools (Grades VII, VIII and IX).
2. Specific objectives:
   a) Modification of Scottish Integrated Science scheme to suit Malaysian conditions;
   b) To produce relevant materials such as pupils' worksheets, teachers' guides and prototype apparatus as support materials;
   c) Re-orientation of teachers.

Project development, implementation and evaluation

Bilateral arrangement was made with the U.K. to help in conducting teacher orientation courses beginning in August 1968. The syllabus was modified from the Scottish Integrated Science scheme, together with similar modification of the pupils' worksheets and teachers' guides. The project developed apparatus lists, test items, prototype apparatus and newsletters.

Beginning in 1969, 22 schools were selected to implement the course. Progressive implementation was adopted; in 1970 there were 85 schools using the course, in 1971 there were 240, and in 1975 there were 650. Now only 33 schools have yet to begin to use the course. In-service training courses for teachers and laboratory staff have been conducted every year since 1968. Project members have been making periodic visits to schools teaching the course in order to obtain information for the continuing evaluation and improvement of course materials.

As the course requires much more practical work than do traditional courses, laboratory facilities have had to be increased considerably. More funds were given to schools for this purpose. In addition, 18 equipment and reference centres were set up in various parts of the country for the use of schools in surrounding areas.

Malaysian General Science Project for Upper Secondary Schools

Objectives of the project

1. To develop Malaysian Syllabuses to replace the existing syllabuses of the Cambridge Local Examination Syndicate for the pure science subjects, Biology, Chemistry and Physics in Forms IV and V (Grades X and XI).
2. To construct courses which continue from an Integrated Science course developed for the lower-secondary level (Forms I, II and III) and also to dove-tail into existing courses in Form VI (Grades XII and XIII).
3. To adopt the same teaching and learning approaches as those of the Integrated Science course at the lower-secondary level.

4. To prepare pupils' textbooks.
5. To provide detailed guides for teachers.
6. To construct examinations that are consistent with the aims and objectives of the courses.
7. To re-orient teachers with the content and approach of the courses through in-service training.

Project development, implementation and evaluation

Between 1969 and 1972, there were two main forms of activity conducted by the Ministry of Education. These were: (a) Organization of writing workshops to draw up syllabus topics, produce pupils' books, produce corresponding teachers' guides and prepare appropriate apparatus lists; and (b) Organization of in-service courses to develop a corps of key personnel and familiarize teachers, who have been selected from pilot schools, with the courses content and approach. To help in this exercise, experts in the Nuffield 'O' level courses were invited from England. The participants of workshops were mainly school teachers, together with some officers of the Ministry of Education and a few university lecturers. Prior to this exercise, the basic groundwork and experience were laid through a number of exposure courses conducted by the British experts in Nuffield 'O' level courses.

The trial materials for both Forms IV and V were each used for two consecutive years in a number of pilot schools. The number of pilot schools increased from 23 in 1972 to 72 in 1973. As the trial materials were being used in the pilot schools, information concerning them was collected as feedback for evaluation and revision. The revised Form IV materials were in use from 1974 and those for Form V from 1975. Up to 1975, the number of schools that were using the courses was as follows:

Year	No. of schools
1972	23
1973	72
1974	130
1975	148

In general, schools are consulted for their readiness to introduce the courses to their pupils. Those that wish to introduce the courses in their schools are expected to say that they are prepared to do so the following year. As preparation for this, these schools send their selected teachers to attend in-service courses conducted by the Ministry of Education, as well as make plans to re-equip their science laboratories according to apparatus lists officially prepared for the courses. Usually the re-equipping of science laboratories is done by spreading the purchases of laboratory items in terms of priority over a few years and completed with careful administration of annual science grants to schools. The 20 equipment and reference centres in various parts of the country also provide a loan service to schools in the vicinity that are doing the courses.

The total cost of the project will be approximately three million Malaysian dollars by the end of the project period in 1981, by far the largest item being spent on the teacher re-orientation programme.

Malaysian General Science Project for Upper Secondary Schools

The target population for the project comprises the pupils of grades X and XI in the Arts stream. The project is aimed at all secondary schools in Malaysia.

Objectives of the project

1. To develop a course in General Science for pupils in the Arts stream at the Upper-Secondary stage that will replace the existing General Science syllabus of the Cambridge Local Examination Syndicate.
2. To construct a course which maintains continuity with the Integrated Science course developed for the lower-secondary stage, and serves as a terminal course.
3. To adopt the same teaching and learning approaches as those of the Integrated Science Course at the lower-secondary stage.
4. To provide detailed guides for teachers.
5. To prepare pupils' textbooks.
6. To construct examination papers that are consistent with the aims and objectives of the course.
7. To re-orientate teachers through in-service courses with the content and approach of the course.

Project development, implementation and evaluation

The Ministry of Education called a planning workshop in December 1971, consisting of eight school teachers, seven officers of the Ministry of Education, and six university lecturers. Broad objectives were drafted and suggestions of course topics were listed. In 1972, the list of course topics was modified in a writing workshop to produce the materials for the Form IV pupils' book and teachers' guide, with the advice of British experts in the Nuffield Secondary Science Project. The Form IV books were completed and printed in 1973, followed by an orientation in-service course using these books for selected teachers. At the same time, a second writing workshop for the production of materials for the Form V pupils' book and teachers' guide was held. These Form V books were then printed in the following year.

In 1974, the Form IV course was introduced into 33 pilot schools. The following year, these 33 pilot schools moved on to the Form V course while a further 18 schools began using the Form IV course.

A process evaluation programme was begun in 1974. It is expected that, by 1978, revised editions of the course materials will have been produced together with other supportive materials, teaching aids, teacher training materials and handbooks.

The total cost of the project is expected to be approximately four million dollars by the end of the project period. The biggest portion by far will be spent on the teacher re-orientation programme.

Primary science and mathematics project

Prior to 1968, the Ministry of Education had been concerned about the unsatisfactory performance based on test results of pupils in rural primary schools in science. Many primary school science teachers were unfamiliar with content and teaching approaches.

Objectives of the project

1. To prepare guide notes for teachers which will both provide some background content material and introduce an enquiry and activity approach to assist them in implementing the existing syllabus.
2. To conduct in-service courses for teachers in schools in order to assist them in understanding the philosophy and pedagogy of the new approach, and how these can be implemented in schools.
3. To establish communications between various personnel involved in the introduction of the project's materials through seminars, discussion groups and newsletters.

Project development, implementation and evaluation

Since 1968, work on the production of teachers' guide notes was done progressively by grades, beginning with the Standard-1 guide in 1969, until the Standard-6 guide was completed in 1975. The implementation rate of the project was determined by the production schedule of these guides which were mailed to all primary schools as soon as they became available.

In-service courses are conducted centrally for selected key personnel who later conduct similar courses for other teachers in their surrounding area. These centres where in-service training is conducted by key personnel are located in various parts of the country, and are designated as Activity Centres. District and Residential Training Centres have also been set up. Periodic visits to schools are made by project staff as well as key personnel as one form of follow-up activity. Newsletters have also been circulated to schools. An evaluation programme was started in 1971 for the earlier materials produced. Information from this will be used for revision of project materials. In 1974, the Curriculum Development Centre began to develop multi-media self-instructional modules aimed at improving selected skills of primary school teachers.

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NEPAL

General background

Before 1971, the education system of Nepal was influenced by successive waves of impact from India–the Aryans Hindu, Buddhist, Mogul and finally the British system of education gradually superimposed themselves one upon another. Because of changing needs of the country, the latter system was not suitable due to several major drawbacks. Educational policies and objectives were not well-defined. Education was not functional as it did not enable students to be self-sufficient. It was not work-oriented, so it failed to produce middle-level manpower, which this country needed badly. That system was based on an unproductive value of society, because it was looked upon as a means of avoiding manual labour.

As attempts to remedy the situation, the Nepal National Education Planning Commission appointed in 1954, the Nepal All-Round National Education Committee appointed in 1961, an invited Unesco team in 1962 and a number of experts thereafter, suggested to His Majesty's Government ways and means to reform Nepal's archaic educational system. The National Educational Advisory Council constituted in 1968 also suggested the need for reform of the education system. As a result, His Majesty's Government under the wise direction and guidance of His Majesty King Birendra produced a new five-year National Educational System Plan (1971 to 1976).

Present educational structure

Pre-primary education (ages 4–6). His Majesty's Government has not undertaken to open pre-primary educational institutions for the time being. Individuals or associations wishing to establish and manage pre-primary institutions must have prior approval of the Government. Many children get their pre-primary education in their homes where their parents and elders teach them reading, writing and arithmetic.

Primary education (ages 6 to 8, grades I through III). The aim of this level of education is to impart literacy. In these grades, boys and girls are taught reading, writing and arithmetic, some knowledge of Nepalese and general information regarding the King and the country. It lays emphasis on the development of general knowledge.

Nearly 64 per cent of boys and girls in this age group are supposed to have the opportunity of primary education according to the National Education System Plan. His Majesty's Government has managed free primary education for the whole country and the government bears all the expenses (teachers' salaries, teaching materials and miscellaneous expenses) for primary education. The Government has made good standard textbooks available *free* to all children in remote areas and to at least 15 per cent of students in the remaining parts of the country. To maintain the same standard for primary education in the whole country, H.M.G. has managed district-level examinations at the end of the primary school term.

Lower-secondary education (ages 9–12, grades IV through VII). The aim of this stage is character building by cultivating loyalty to the King and the country. Another aim is to initiate pre-vocational education to develop a sense of the dignity of labour. Language and arithmetic are taught in more detail and extra-curricular activity is emphasized.

Lower-secondary education facilities have been extended to at least 40 per cent of the primary school students, and H.M.G. is granting financial assistance to cover full salaries of the teachers in the remote districts and 75 per cent in other districts. A zonal-level examination is conducted at the end of the lower-secondary school term.

Secondary education (ages 13 to 15, grades VIII through X). The aim of this stage is to build useful citizens by laying special stress on vocational education. Vocational training is compulsory and is designed to produce skilled workers. There are three types of secondary schools:

a) General secondary schools, where general subjects form 80 per cent and vocational subjects the remaining 20 per cent of the school hours.

b) Vocational secondary schools, where vocational training covers up to 40 per cent, and general subjects are given correspondingly less importance.

c) Sanskrit secondary schools, where the main emphasis is on the learning of Sanskrit.

Nationwide examinations have been arranged at the end of the secondary school term. A passing grade merits the School Leaving Certificate.

Higher education. Higher education has been organized to meet the manpower requirements of the country, based on nationwide estimates. Its aim is to maintain a high standard of teaching and study.

Institutes of different subjects have been set up under the Tribhuvan University. Of 16 institutes, eight are technical institutes. The six-monthly semester system has been applied to higher education. At the end of each stage a comprehensive university examination is held to promote the students to the next stage.

The university organizes a separate entrance examination to determine the eligibility of students for higher education. Proper arrangements are being made to reduce the number of those taking up arts and humanities and increase the number who select technical subjects. Preferably, opportunities are given to low-level technicians to join higher-level technical institutions, provided they pass the requisite entrance tests.

Educational administration and supervision

All levels of schools in a district are run under the administration and supervision of the District Education Office. This office, with the help of school supervisors, maintains direct contact with the district educational institutions. The school supervisor ratio is 1/30 and 1/13 respectively for primary and secondary schools in 'Tarai' (plateau) areas and 1/20 and 1/9 for primary and secondary schools in hilly areas.

District education offices are instructed and directed by regional directorates. Four regional directorates have been set up, one-each in the East, Central, West and Far West Zones. Each directorate is responsible for guiding, co-ordinating and supervising the execution of educational policies and objectives. The directorate is charged with organizing training programmes, seminars and inspections in the interest of maintaining the prescribed responsibility and standards of education. All the directorates function under the Ministry of Education. To facilitate the implementation of education policy and activity, the Ministry of Education has been divided into the: (1) Planning, (2) Administrative, (3) Technical and (4) Evaluation Divisions. The Secretary of Education is the principal executive of the Ministry of Education, and all four Divisions work under him.

Under the present education policy in Nepal, higher education has been correlated to the job opportunities of the future. The teaching profession has been given higher status to make it competitive with other professions. In the educational institutions, proper provisions have been made for programming extra-curricular activities, cultivating an intellectual atmosphere and promoting active student participation in nation building. The curricula of different levels of education have been made uniform throughout the country. Internal assessments and periodic examinations have been held in close co-ordination in all grades at all levels.

The National Development Service (NDS). Arrangements have been made for every student receiving higher education to go to a village and perform civic services for one year under the National Development Service Scheme after passing the third or fifth years of higher education. NDS is divided into four corps: (a) Education, (b) Health, (c) Agricultural and (d) Construction Services.

Curriculum Development Centre. The Curriculum Development Centre (CDC) plans and prepares suitable curricula for each subject. It has organized separate sub-committees for every subject taught at school level. The sub-committee for science and vocational subjects consists of representatives from the Institute of Education, vocational training centres, and science and vocational institutes. Specialists and experts of concerned subjects, technicians from concerned industries and factories, teachers and headmasters are invited.

The drafts of the curricula prepared by science and vocational subject sub-committees are sent for discussion to a Development Committee which includes specialists of all the subjects working under the CDC. After endorsement by the development committee, the curriculum drafts are sent for approval to a co-ordination committee constituted under the Chairmanship of the Education Minister, with highly qualified persons selected from different fields and offices.

Keeping in view the objectives and contents of science and vocational curricula of secondary and lower-secondary schools as prepared by the Curriculum Centre, the Institute of Education prepares training curriculum for teachers.

Science education at the second level

The first level of school does not include science as separate subjects. The 'social studies' curriculum of primary school, however, includes elementary knowledge about natural science.

The main objectives of science education at the second level are: (a) to develop working skills in science such as observation, communication, measurement and drawing; (b) to enable children to get functional knowledge of nature by being actively involved; (c) to develop creative thinking and logical reasoning; (d) to develop a fundamental knowledge of scientific terms, facts, concepts, and generalizations concerning matter and energy; (e) to develop scientific attitudes.

Science education as a separate subject starts at grade IV in the present curriculum. The development of scientific methods and laboratory skill have been mainly emphasized in lower-secondary science curriculum. Science education is compulsory for each student at the lower-secondary stage. Students of general secondary schools have to study more science content than those of other types of secondary schools. The upper-secondary school science curriculum covers almost all branches of science: physics, chemistry, biology, geology, human physiology and astronomy.

Environmental education, the conservation of plants and animals, and the study of simple ecosystems has been emphasized in both lower- and upper-secondary curricula.

Education in out-of-school programmes. Informal science education has not yet been started in Nepal, although a functional adult education programme in agriculture has been started in recent years in some selected districts. The vocational agriculture teachers and the junior technical assistants of the Agriculture Department have been asked to conduct functional adult education classes in the evening for the villages around secondary schools. The Minister of Education has developed a curriculum for the above programme and has provided funds to carry it out.

Institutional arrangements and instructional materials. Five out of the 12 campuses of the Institute of Education have made arrangements to produce science teachers. The Janak Educational Materials Centre (JEMC) publishes textbooks and teacher's guides on a very large scale to meet the needs of the entire kingdom. It then makes necessary arrangements to distribute them to every part of the country through its own agencies. There is a science equipment centre running under the JEMC which has produced nearly 60 items of simple prototype science equipment. This equipment is distributed through regional directorates.

His Majesty's Government has granted all the finances for the purchase and supply of the equipment and tools. Most of the science equipment, chemicals and vocational tools are purchased from India and distributed to schools through regional directorates.

Training educational personnel. The Institute of Education and its branch vocational training centre have taken the responsibility of producing vocational and science education supervisors. The CDC and the Examination Sub-division of the Ministry of Education make necessary arrangements for training supervisors, teachers and other personnel, giving essential feedback about curriculum implementation and evaluation techniques. The Regional Directorates and District Education Offices arrange training workshops and seminars for headmasters, teachers, and supervisors.

Research and evaluation

The New Educational Reform Associates have recently completed research on "Study of the supply and utilization of educational materials at the school level in Nepal." The research report makes suggestions and recommendations for the supply and utilization problems of educational materials.

The specialists of science and vocational subjects in CDC have made a survey of local resources in one district (Lalitpur) through selected and concerned subject teachers of that district for experiment. After completion of the survey of local resources, educational materials were prepared, tested and modified. Finally, a handbook was prepared to be used for that district in all schools.

To evaluate the science and vocational curricula the CDC has begun curriculum analysis in two directions:

1. Field study – To observe classroom teaching of science and vocational subjects, to collect essential information about how the curriculum is utilized in the field.
2. Content analysis – To study the relevance of :
    a) Objectives with respect to level;
    b) Objectives with respect to contents;
    c) Scope and sequence with respect to level;
    d) Activities with respect to objectives and facilities;
    e) Textbooks, teaching units and teacher's guides.

For this purpose, suitable questionnaires were distributed to teachers, headmasters, supervisors and other concerned persons, and personal interviews were conducted. It has been realized that activities to teach those subjects should be planned in such a way that they can be met by local resources. After study of the questionnaire, the future trends and objectives of curriculum reformation can be detected.

Out of 60 prototype science equipment items produced by the Science Equipment Centre, 19 have been selected for mass production, because these are the least expensive and the most useful.

Since the old lecture method for teaching science and theoretical parts of vocational subjects is predominent, discussion and demonstration methods are now being emphasized more strictly.

Mention has already been made of the new trends to utilize community resources for teaching aids, especially in science and vocational education. Now, it is also realized that *community problems like sanitation, immunization, water supply, living conditions, chicken disease, communicable disease, and conservation of water, land and forests must be utilized as teaching resources.*

To emphasize the development of practical skills in science education, an optional science curriculum is being prepared which accommodates both practical work and theory. Even the general science curriculum is being divided into practical and theoretical parts.

Identification of problems

Problems in the field of science and technology education can be broadly classified into four basic groups.

1. Meeting the shortage of suitable manpower:
   a) The institutions are not getting as many qualified teachers (B. Sc. and I. Sc.) as they need.
   b) Most working teachers are untrained in teaching methodology.
   c) Even among working teachers, one who has studied physical science is unable to teach the biological part of the science curriculum. Similar problems crop up with the biology teachers.
   d) Training opportunities provided to science teachers and vocational teachers are not sufficient.
   e) Working teachers lack essential instructions and feedback.
   f) Teachers have to teach an average of more than 28 periods per week, and the classes may contain as many as 60 students in one section.
   g) This country also lacks trained educators who can train science and vocation teachers efficiently.
2. Lack of physical facilities:
   a) Most of the schools do not have a room big enough to be set aside for science teaching. These schools also lack safe and suitable store-rooms for science materials.
   b) The government has managed to supply equipment only once by importing from India. But after some use there is no management to resupply consumed chemicals and broken equipment parts. Convenient markets for these things are not available in Nepal.
3. Having no separate science education sub-division:
   a) The development of science education is of vital importance for the development of the country. Science education therefore needs continuous planning, research, evaluation and training work. This will be possible only when a separate science education division is established to be directly responsible for all of these activities.
   b) For science and technical education activities, separate budgeting is required.
4. Need to review curricula:

Curricula were prepared in the beginning of the implementation of the current plan for the first time for the school level. Therefore, due to lack of experience in constructing curricula, the following defects have been found there :

a) In some cases the content of science curricula are not in proper sequence.

b) Proper co-ordination could not be done between mathematics and science curricula; therefore difficulties have arisen in making science concepts understandable due to the absence of essential mathematical background.

c) The objectives by level and grade of science are not properly specified. Therefore, the teachers lack understanding of what to teach them without training, background and proper communication.

d) The same curriculum has been accepted for the whole kingdom; therefore remote areas are facing difficulties due to lack of qualified teachers and sufficient physical facilities.

Brief description of future plans

1. To raise the teaching standard of science and vocational subjects, a short period of intensive training for teachers is being planned.
2. The necessary information about science education will be given to all supervisors in the near future.
3. The Institute of Education will be requested to create a fixed quota for science teachers in coming years to train and produce science and vocational teachers in a required number.

SELECTED SUBJECT ALLOTMENTS

Table 1. Subjects for primary level: grades I to III

Subjects	Percentage of school time
1. Nepali language	40
2. Arithmetic	30
3. Social studies	20
4. Physical education, hygiene, handicrafts and drawing (all taught through practical activities)	10

Note: Social studies includes basic science teaching.

Table 2. Subjects for lower-secondary level: grades IV to VII

Subjects	Percentage of school time
1. Nepali language	30
a) Nepali language (grades VI, VII)	25
b) Elementary Sanskrit (grades VI, VII)	5
2. One of the United Nations languages	10
3. Social studies	13
4. Mathematics	20
5. Science	10
6. Pre-vocational training	10
7. Physical education and hygiene	7

Table 3. Subjects for general high schools grades VII to X

Subjects	Percentage of school time
1. Nepali language	12
2. One of the United Nations languages	12
3. Mathematics	12
4. History and geography	12
5. Health education	5
6. Panchayat	5
7. Science	12
8. One of the vocational subjects	20
9. Optional subjects (one from among the group below)	10

Optional group : Sanskrit, English, French, Russian, German, Japanese, Portuguese, Spanish, Chinese, Hindi, Tibetan, Urdu, Arabic, Persian, Maithily, Bhojpuri, Newari, Additional Mathematics, Additional Science, Human Physiology, Rural Economics, Domestic Science (for girl students).

SELECTED SCIENCE EDUCATION PROJECTS

Development Educational Equipment Prototypes

This project was started in 1972 with a target population of secondary school students. It was launched in order to design and develop educational equipment to suit the needs of curriculum development under the New Education System Plan. Under the project, educational equipment prototypes have been designed with the following considerations:

1. Utilization to the maximum extent of local raw-materials and labour;
2. Suiting the equipment to the needs of the curriculum.

Needs in science equipment in relation to curriculum were determined in consultation with the CDC, and a survey of available local raw materials was conducted. Equipment literature was studied and models were designed and prepared. The two kinds of prototypes being considered are: (a) equipment which is to be made by teachers and students themselves in schools; and (b) equipment which is to be produced in a centre.

The personnel for development work have been trained and educational equipment prototype development has been initiated. The Science Equipment Centre produces prototype equipment in consultation with the CDC and science teachers from schools. Field tests and trial of the equipment are carried out in co-ordination with the Institute of Education (IOE). About 65 prototype items of equipment have been developed so far; mostly science equipment although some of them are vocational.

For the first time educational equipment has been designed and developed in Nepal. The equipment is being evaluated by the IOE, and experiments are being performed in a classroom situation.

The yearly budget amounted to approximately Rs. 200,000. This budget covers expenses involved in repair maintenance work. UNICEF provided machine tools for the project.

More educational prototype equipment is to be designed and developed, so the project will be continued to achieve this goal of promoting science education in Nepal. More co-ordination of the agencies involved will be needed.

A production unit

This project was started in 1974 to provide low-cost equipment by reducing the import of expensive equipment. Objectives of the project:

1. To provide low-cost equipment to schools;
2. To move toward national self reliance in the production and supply of equipment to schools.

The project was designed with the following considerations:

1. Mass production of equipment designed and developed under the previous project.
2. Utilization of local raw materials in producing the equipment.

A pilot production of some selected equipment was first carried out. Then, about 13,000 pieces of 19 different items of educational equipment were manufactured under this scheme. The equipment was only recently distributed to schools, so no evaluation has been conducted so far.

The establishment of a unit for education equipment production is under consideration by the Ministry of Education. Production will be planned after assessing the equipment needs of the schools of the Kingdom.

A handbook for manufacturing and maintenance of simple basic equipment

The aim of the project is to educate the teachers in manufacturing and maintenance of educational equipment in the classroom. A science bulletin has been published and distributed to secondary schools. Further bulletins are planned.

The Ministry of Education is preparing a proposal for two more projects to be conducted in future.

It has already been mentioned that specialists of science had made a survey of local resources in one district for experiment. That experiment proved to be fruitful. Therefore, a project is to be carried out to survey the local resources in the other remaining districts of Nepal. The science specialists, teachers and supervisors will be involved.

A second project is to be launched with the following overall objectives: the promotion of increased working understanding in science, mathematics and vocational subjects in the schools, through the co-operative development of a system for producing and testing equipment and materials, and for training teachers in the use of appropriate educational technology and procedures.

Bulletin of the Unesco Regional Office
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NEW ZEALAND

The New Zealand Education System

In 1975 the primary school population numbered 518,600, the secondary 229,800. The average time spent at the second level by school leavers was 3.5 years. More than 50 per cent of pupils complete four years of secondary education and 16 per cent of girls and 22 per cent of boys complete five years. Figure 1 provides a summary of the structure of education in New Zealand.

The central government provides the full cost of education (5.5 per cent of GNP) in New Zealand public schools; this is administered through the Department of Education. At local level, control lies with ten elected education boards in the case of primary schools, and individual boards of governors for secondary schools. An inspectorate appointed by the Department of Education exercises professional leadership and control but, within schools, head teachers have power to organize the curriculum within the broad national guidelines prescribed by the Minister of Education.

The broad objective of the education system is to provide for every person the education "for which he is best fitted and to the fullest extent of his powers." Today it is plain that schools are only one important institution in society with a stake in the provision of equality of educational opportunity. Schools attempt to provide an example of democracy in action, to promote opportunities for coming to terms with cultural differences in the New Zealand setting, play a role in the development of the national economy as well as the personal development of individuals. It is worth noting that in the last decade there has been a marked decline in pre-vocational training courses given in secondary schools. Associated with this has been the growth of vocational training at the tertiary level. Increasingly, employers expect to find among school leavers evidence of a sound general education with competence in English and Mathematics. Schools are responding by re-thinking their approaches to the general education of their pupils.

Planning mechanisms for science (and technical) education

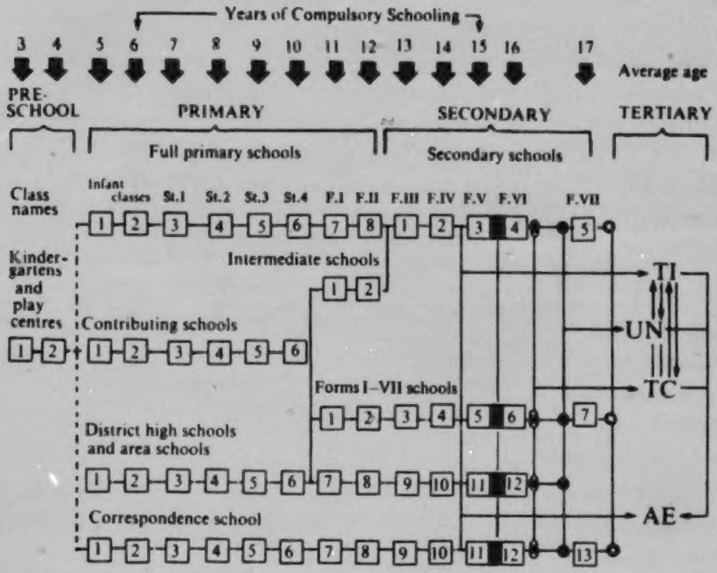
Agencies responsible for national examinations are:

1. University Entrance Board (UEB)–University Entrance (Form VI)
   University Bursaries/Scholarship (Form VII)

2. School Certificate Examination Board–School Certificate (Form V)

Syllabuses prescribed by these Boards include: University Entrance and Bursary–biology, chemistry, physics, technical drawing (UE only); School Certificate: science, biology, human biology, chemistry, electricity, physics, animal husbandry, general agriculture, horticulture, applied mechanics, engineering shopwork, technical drawing, woodwork.

FIGURE 1. THE NEW ZEALAND EDUCATION SYSTEM


Years of Compulsory Schooling
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Average age
PRE-SCHOOL
PRIMARY
SECONDARY
TERTIARY
Full primary schools
Secondary schools
Class names
Infant classes
St.1
St.2
St.3
St.4
F.I
F.II
F.III
F.IV
F.V
F.VI
F.VII
Kindergartens and play centres
Intermediate schools
Contributing schools
Forms I–VII schools
District high schools and area schools
Correspondence school
TI
UN
TC
AE

KEY

TI – Technical Institutes
UN – University Institutions
TC – Teachers' Colleges
AE – Adult Education Courses

■ School Certificate
● Form VI Certificate
• University Entrance
○ Higher School Certificate or University Bursary or Scholarship

Form I–VII School: A school in a rural centre providing an integrated course from Form I to Form VII.

District High School: A primary school with a secondary department attached in a small rural centre.

Area School: A school in a small rural centre providing an integrated course from infant classes to Form VI for children from its immediate neighbourhood and from Form I to Form VI for pupils from a wider area.

The Form VI Certificate is a Department of Education certificate assessed internally by schools and is an example of schools developing courses to meet local needs. Syllabuses in any subject may be developed against the criteria that the programme represents work one year in advance of School Certificate. Technical drawing, building construction, workshop technology and science are subjects presently offered.

Since its formation in 1963 the Curriculum Development Unit has been responsible for keeping under review the school curriculum from the infant classes to Form VII. Its role includes co-ordinating the curriculum activities of all interested parties such as the New Zealand Educational Institute, the Post-Primary Teachers Association, the inspectorate, the national examination boards, university interests and professional body interests. When pressures indicate revision is needed, revision committees, representative of all branches of the education service, are established under the authority of the Minister of Education. This initiative is taken within the Department of Education except for examinations controlled by the Universities Entrance Board, which establishes its own revision committees.

When a revision committee has completed its work, the Curriculum Development Unit, alone or in association with the Schools Publication Branch, the Visual Production Unit and the National Film Library is responsible for preparing guidelines and up-to-date teaching materials for the new courses. Where new or additional equipment is involved, the introduction of the new course is delayed until the necessary finance is approved.

A national curriculum has been developing as distinct from a set of syllabuses. Each subject area is being developed on the basis of a common pattern involving the statement of precise objectives in terms of intended changes in pupils' cognitive and affective behaviour, the drafting of learning resources designed to achieve these objectives, the trial and appraisal of these materials in schools, and then revision in the light of the trials prior to publication and dissemination.

Science education in primary schools

Until recently, traditional primary science has been associated with nature study or the biological sciences—especially in the junior classes. In the past decade the development of a new science syllabus for children up to Standard 4 has been evolving. This represents an important shift in emphasis in that it is attempting to have the principle recognized that the whole field of human endeavour generally regarded as science should be utilized in learning situations for the development in children of the cognitive and physical skills, and the attitudes and interests deemed important for continued learning and living. The new type may be regarded as 'undifferentiated' science although, for planning purposes, four broad areas of scientific knowledge and experiences are identified for development.

At the Forms I and II stage (11/12-year-olds) a science syllabus is taught which was developed eight years ago. Major problems have been in the scale of equipment in schools and the relative standard of personal science education of primary teachers.

Science education in secondary schools

All pupils take the subject science in Forms III and IV. At Form V a number of options for School Certificate Examination may be chosen: (a) no further science education; or (b) choose one, two and sometimes three subjects from those listed earlier. The majority of students (50–60 per cent) choose one subject, Science, a significant number Biology (25 per cent), less than 10 per cent Physics and Chemistry and fewer still the other subjects. Within these figures some pupils could be taking two subjects. Most schools tend towards a policy of a broad science education to the Form V stage preferring to introduce the specialist subjects in Form VI, for which the subject Science was designed as a base.

In Form VI, students may take any of the three specialist sciences (Biology, Physics, Chemistry) offered for University Entrance. Schools accredit UE candidates and those not accredited take an external examination. Successful students may continue study in these subjects in Form VII for the Universities Bursaries Examination (external), or Higher School Certificate (accredited).

In 1976, three new School Certificate subjects were on trial in 40 schools—Biological Science, Physical Science and Alternative Science. These subjects, based on a modular approach, offer a considerable choice of course and will be *internally* assessed for School Certificate Examination purposes.

All teachers are able if they so wish to conduct lessons in situations or places away from the school most appropriate to the topic being studied. To help such activities, all education boards and many secondary schools have established centres in suitable rural areas, where classes may be taken for up to a week. Studies in such areas are related more to biology and earth sciences than the physical sciences.

Curriculum panels or standing committees for the various subjects are established by several means, as listed overleaf.

1. Department of Education—subject standing committees appointed by the Director of Secondary Education. Members are Curriculum Officers and Inspectors.
2. Post-Primary Teachers Association (Secondary); New Zealand Educational Institute (Primary). Both organizations have national subject curriculum panels. Membership—Teachers.
3. Teacher Subject Associations. Locally based, *ad-hoc* group of teachers with a professional interest in improving the teaching/learning activities related to science and technology.
4. Professional Bodies such as the Royal Society. Education panels which take an interest in Science and Technology curricula.

Development and supply of instructional materials

Equipment is supplied to all schools by the Department of Education, although this is largely delegated to Education Boards in the case of primary schools. The basic scale of equipment is determined by the inspectorate, Curriculum Development Unit, and Schools Development Section working within defined financial limits. Periodically the basic scale is reviewed and revised. In addition, schools receive yearly grants, part of which may be used in acquiring equipment additional to the basic scale and for normal running expenses. Likewise, textbook grants are made to all schools, based on a scale related to class levels and number of pupils. Schools decide for themselves how the grant should be spent.

The development of instructional materials by classroom teachers is encouraged and their efforts supported by Departmental agencies such as the Visual Production Unit and the National Film Library. The most effective methods involve small working parties which produce draft materials. The CDU and—in local areas—advisers, prepare the drafts for classroom trials, collate feedback and work with the original working party to revise it before organizing publication for general distribution. Such material is provided free to schools; additional quantities may be purchased.

Extra equipment for specialist purposes can be obtained through two avenues: (1) special grants from the Department of Education and (2) fund-raising activities by a school.

Training of teachers

Most primary teachers enter a Teachers College with University Entrance or Higher School Certificate. The three-year training period includes a minimum time of about 25 hours related to science education in primary schools, and students elect certain major and minor courses. In this way a proportion of each class receive some training in depth in primary science education. These people later become resource teachers in schools. A continuing programme of in-service education (of primary teachers) in science is organized through the inspectors, and science advisers attached to each education board district.

In secondary schools, science teachers take a three- or four-year degree before undertaking a one-year course of teacher training at a Teachers' College. The degree structure tends to produce specialist subject teachers but the years' training is in part aimed at broadening the teaching base. Continuing support of science teaching is now being given by Science Advisers. These advisers are successful secondary teachers seconded to the advisory position for intervals of up-to two years. With the appointment of these advisers, an increasing amount of curriculum development, especially of resource materials, is being undertaken at the local level.

Demand for continued education or in-service training continues to be greater than resources will allow. Week-long residential courses (of up-to 26 teachers) are conducted in the two in-service training centres. Each school district (primary and secondary) has non-residential in-service training centres where courses ranging from one day to six weeks are conducted. Evening classes for teachers have been run when needed. In these types of courses teachers remain on full pay and their expenses are reimbursed. Relieving teachers can be employed by the schools affected. In vacation time, the Teachers' Refresher Course Committee organizes large scale one- or two-week courses, which are heavily attended. Only travel costs are refunded to teachers. Again, science teacher organizations organize workshops in evening or weekend sessions.

These activities are usually mounted by the Curriculum Development Unit although the teacher bodies' organizations also undertake limited surveys. Research is aimed at obtaining information and data which enable draft resources to be improved, new courses or approaches to be evaluated against intended outcomes, and the effectiveness of programmes to be assessed in the long term.

Trends in science education

Curriculum development. In the past six years, new syllabuses have been introduced in all science subjects at Forms VI and VII, while the subject Science has become the most widely taken subject at Form V. Three new School Certificate subjects have been on trial in 1976–7. All the new syllabuses include a statement of objectives in which some common element can be recognized. These can be grouped as seen overleaf.

1. Knowledge objectives. Relevant knowledge of facts, concepts and principles.
2. Process objectives—the cognitive and physical skills deemed essential for further learning and living.
3. Attitudinal objectives—interest and awareness of the effects of topics studied on the environment and on personal relationships.

These statements then guide the choice of content. A change in emphasis within these groupings can also be seen. Syllabuses developed in the late 1960s tended to emphasize development of concepts in the choice of content. More recently the processes of cognitive thinking, the physical skills, attitudes and interests have been considered more important in choosing content especially in the earlier years. However, examination syllabuses at School Certificate, University Entrance and University Bursary identify concepts and principles students are expected to master and these tend to dominate because they are most readily examinable. A trend towards individualized learning can be discerned.

Teaching/learning materials. With all new syllabuses, teachers' guides are produced to assist teachers with implementation. Initially, for resource materials, teachers rely on those already available, but new texts and items of equipment invariably appear as experience with the innovation grows.

It is emphasized that in all developments teachers are involved at every stage. These teachers are in a strong position, once the initial development phase has been completed, to be associated with the further writing of textual materials, and a large number have become involved in this way. Science teacher organizations also are active in encouraging the exchange of ideas.

New instructional methodologies. There is a growing trend towards mixed ability or unstreamed classes which is calling for a new range of teaching skills and resource materials. There is general acknowledgement that students learn at different rates, in different ways, and that interest and ability affect these. Even in streamed situations these factors apply to a less marked degree. This awareness creates a demand for resources and classroom organization which would allow pupils to progress at individual rates. A greater range of audio-visual media as well as textual materials, references and structured practical work is required in all science subjects and at all levels. Teaching skills related to the management and deployment of such resources and new types of classroom interaction are not acquired quickly, but efforts are being directed by CDU towards the development of appropriate resources, while study groups and some in-service courses are developing patterns for forms of co-operative teaching and integrated/interdisciplinary studies. New concepts in school design (e.g., open plan) are evolving in the belief that new schools should be sufficiently flexible to allow a range of teaching/learning patterns.

Preparing teachers. The usual way of preparing teachers for innovation has been and remains in-service training. Another approach has been the involvement of many small working parties, distributed geographically through New Zealand, contributing to the developmental phases. In this way a large number of teachers become aware of an activity and try to find out more about it, while those involved have an interest in seeing the material used. Again trial materials are distributed widely although evaluation is conducted in only a sample. Other teachers may use trial materials and comment if they wish. Teachers are thus prepared for new programmes free of any pressure to meet deadlines or prescribed requirements.

Inter-relating science education and technology education. Up to the present, science education and technology education have been conducted as separate areas of study. In structuring courses schools do ensure that students taking a technology-orientated course include appropriate science subjects. In the upper-primary and lower-secondary stages, all pupils include separate science and technology studies in their core activities. Future developments envisage a more integrated approach than presently exists.

Utilization of community resources. Schools and teachers are encouraged to use community resources in their programmes, but the extent to which this occurs varies with the enthusiasm of individuals. There are outstanding examples of schools and communities working together on environmental problems. Again, many business enterprises are offering assistance with resources—filmstrips, photographs, films, kits of materials, some on request from schools, others on a national basis in association with the Department of Education.

Evaluation methods and trends. Evaluation of innovation in science involves wide consultation with teachers, schools and others affected. Decisions by national committees are made only after comment on draft proposals reaches a consensus. At that stage, resource materials can be prepared. Both the proposals and resource materials are placed on official trial in a representative sample of schools, and feedback from teachers, pupils, and independent observers collated by the Curriculum Development Unit. Revision is then carried out and, if necessary, a further trial is conducted. Once the controlling National Committee is satisfied that the proposals meet the standards of their brief, are acceptable to the teacher organizations, and can be supported by the necessary resources, the recommendation is made to the appropriate authority that the innovation be promulgated.

Science education is being developed as a continuous process from infants through to Form VII students with emphasis on student activity and a wide range of experiences. In primary and lower-secondary education it is seen as an important area of human endeavour which should contribute to the general development of children. In this way a knowledge of science activities is used to develop skills and attitudes that young people will use in their lives. As pupils progress through the secondary school, the separate science disciplines become more differentiated and studies focus more on the development of subjects. The trend is to delay study of specialized disciplines as long as possible and to this end a modular approach to science education at School Certificate level is on trial.

Problems and future plans

In the past half-century New Zealand has moved from an education system based on selection and privilege to a form which caters for the whole population. Problems have arisen from the rapidly expanding population, the steady increase in average age of school leavers, and changing social and economic conditions. For the past three decades, New Zealand has experienced crises with teaching space and teacher shortages, although the latter are now much less acute. Science education in the primary school has been affected by class sizes, the personal science education of teachers, and difficulties in providing appropriate teaching space and equipment. In secondary schools, the upsurge in popular demand for a science education aggravated the teacher shortage for two decades while great strain was placed on science teachers by changes in syllabuses at all levels. Now the escalating costs of capital equipment and providing for more individualized programmes of work are likely to affect the quality of both teaching and learning.

In the primary school, the 'Draft Science Syllabus for Infants to Standard 4' will be implemented over a three-year period. For School Certificate, three new subjects based on a modular approach are being tried-out: Biological Science, Physical Science and Alternative Science. The science syllabus, Forms I–IV, will be modified in the light of eight years' experience and the outcomes of the Form V trials. At University Entrance and University Bursary stages new prescriptions in Biology, Chemistry and Physics have been introduced in recent years and developments are aimed to support the trend towards individualized learning in these subjects.

SCIENCE EDUCATION PROJECTS IN NEW ZEALAND

Form V Science Revision (Modular Science)

Background. In 1970, following the introduction of a new Form I–V science syllabus, a national conference considered the position of science in Form V. It recommended investigation of two schemes:

1. Science plus two new subjects, biological science and physical science;
2. Science plus additional science.

A review committee prepared outline syllabuses in both Biological Science and Physical Science which were circulated, together with a questionnaire, to teachers for comment in 1972. Approximately half of the 3,300 respondents favoured the first scheme given above, while the other half preferred one of four other combinations.

It was clear that any new developments would need to cater for the full range of Form V students and take into account current changes in secondary schools. A reconstituted committee in 1974 proposed a modular syllabus in both biological science and physical science. A recent extension of this proposal to include School Certificate Science followed discussions with members of the School Certificate Examination Board.

The objectives of the project are to develop modules or units of work from which teachers could structure a course in Biological Science, Physical Science and Alternative Science which would:

- provide for individual differences in students;
- encourage students to study individually;
- encourage students to seek knowledge from the descriptions and explanations of others;
- encourage students to operate in group situations and accept that other people do not always see the same phenomena as they do;
- provide opportunities for students to gain satisfaction through involvement.

In developing these courses more emphasis is placed on individual student development, and on methods of learning. The description of the content base of each module has been kept to a minimum in order to allow time for student activity.

Project design and development. Two sets of modules, one for Biological Science and another for Physical Science have been prepared. For each module a general aim and a set of objectives identify the expected learning outcomes. Teachers or schools may select from the modules to construct a course best fitted for the future needs of students. This freedom of choice enables class or individual programmes to be oriented in a number of ways. Because emphasis in all modules is on the processes of learning it is believed that most courses can prepare students for further study and learning in any science area.

In developing classroom programmes teachers are encouraged to use a wide range of media and learning situations. Eventually this is expected to lead to new forms of classroom practice—especially those promoting individualized study. In the trial, teachers have a new responsibility in being required to assess pupils in order to rank them for certification purposes. This is a research and development aspect to determine feasibility and effective methods of procedure for the internal assessment of the three School Certificate subjects.

The freedom offered by this trial has led to a greater degree of consultation between students, their parents, teachers and the school in determining the courses offered. For schools, new organizational problems affecting scheduling, teacher strengths and interests, and laboratory facilities and accommodation have become apparent.

1971–75: The philosophy and statements of modules were prepared by the SCEB Science Review Committee, circulated to schools for comment, and amended in light of the response.

1975: Teachers from key trial schools were brought to a week-long residential course to prepare a number of suggested teaching approaches to each module, and also identify available resources. This material has been provided to each teacher involved.

1976: A committee of CDU officers and inspectors has been established to co-ordinate evaluation and developmental activities during the trials in 1976–77. The 40 trial schools have been grouped in clusters with a cluster co-ordinator. Administrative arrangements have been made for teachers to exchange ideas and materials, and to work together—in local areas—to develop new teaching/learning or assessment material.

Project implementation. As this trial affects the School Certificate Examination, the decision to proceed with the development and implementation was taken by the School Certificate Examination Board. The review committee established by the Board prepared all materials, collated feedback information, and recommended appropriate action to the Board. The Board decided that 40 schools take part in the trial and that it also be used to evaluate methods of total internal assessment for certification purposes.

Initial briefing meetings of schools in clusters were held at the end of the 1975 school year and the organization for maintaining communication between schools, cluster co-ordinators and national co-ordinators was established. Each school reported the subjects it would offer students in 1976, the criteria on which decisions were based, and their organizational arrangements.

Project evaluation. An evaluation programme was established, and information obtained in order to:

1. Determine the teachability of the modules and the teaching styles adopted;
2. Determine the needs for new equipment and resources;
3. Develop in-service training materials;
4. Determine the effectiveness of a flexible modular approach in providing science education at this level; and
5. Determine effective methods for internal assessment for School Certificate.

A national co-ordinator is receiving information from an inspector co-ordinating trials in his district. Cluster co-ordinators gather information from a small group of schools and ensure communication between these schools, then pass the information to the area inspector.

Class teachers have been asked to complete a questionnaire and make comments on each module they teach. Information on successful assessment methods is also requested.

Once each term the Heads of Science Departments in each of the four districts review activities, and visits to trial schools are made by national co-ordinators and inspectors throughout the year.

The results of the evaluation were not available at the time this article went to press.

Infants-to-Standard-4 Science

Background. The intention was to replace the existing primary science syllabus (introduced in 1949) with its emphasis on nature study with a flexible syllabus that provided experiences in four areas of scientific knowledge.

The objectives were established as being to provide a science education that helped a child to:

- Acquire significant knowledge;
- Develop basic concepts;
- Develop process skills;
- Develop an ability to communicate;
- Develop interests and attitudes;

and so develop an enquiring mind and the skills for exploring and interpreting his biological and physical environment.

In 1971, a National Syllabus Committee was established under the authority of the Minister of Education. An official trial of tentative proposals in 100 schools was then carried out. All teachers and schools were invited to take part and were provided with an appropriate trial publication whether they intended to use it or not. Continuous revision was made through 1975.

Project implementation. The period of five years in which teachers were kept fully informed of proposed developments and provided with draft materials with which they could experiment without any pressure ensured a widespread knowledge of the objectives and teaching strategies to be employed in a new syllabus. This approach led to strong pressure from teachers themselves for the official introduction of the new syllabus. In schools, science programmes are now invariably based on proposals contained in the draft syllabus and trial units of work.

Specific comment from all interested parties has been accepted on the statement of the syllabus. These collated comments have been considered by the National Syllabus Committee and decisions about revision made. Teachers have reported on individual trial units of work and they have been observed operating by independent assessors as well. Small working parties have collectively revised units on the basis of this information.

The specific outcome is that when the new Infants-to-Standard-4 science syllabus is declared official, it represents a statement fully accepted by teachers and one known to have been thoroughly tested. Resources to support implementation have been prepared and developed to a high degree. The costs of providing schools with necessary equipment are known and this has enabled budgeting within the national economy and so determined the length of the phasing-in period.

Problems and successes. The major problem in the early stages was that of personnel to control and co-ordinate developments. Initially, inspectors were seconded for short terms to the Curriculum Development Unit to develop working papers, the first draft syllabus, and organize local working parties to prepare units of work. Short-term secondment was increased to one-year secondments, but the yearly change-over of leadership did cause some administrative delays and consequent irritations among teachers. Finally, the appointment in 1973 of a curriculum officer with particular responsibility in primary science stabilized the co-ordinating problem. Meanwhile, the experience gained by inspectors has benefited districts and provided a reservoir of leadership in this area of development.

The second main constraint has been the way inflation and escalating costs over the five-year development have affected the timing and period of national implementation.

A major success has been the development of the units of work to support the syllabus. The syllabus itself presents the philosophy, examples by which achievement of objectives can be recognized, and the range of concepts which can be developed. The units of work state the objectives, provide suggestions for classroom activity and include enough information about the topic to give confidence to a teacher.

Bulletin of the Unesco Regional Office
for Education in Asia
Number 18, June 1977

PAKISTAN

Present state of science education

Educational reforms in Pakistan launched by the People's Government in March 1972 have the following broad objectives which imply an entirely changed role of the teachers:

1. Ensuring the preservation, promotion and practice of the basic ideology of Pakistan and making it a code of individual and national life.
2. Building up national cohesion by promoting social and cultural harmony compatible with our basic ideology through the conscious use of the educational process.
3. Building up and nurturing the total personality of the individual, dynamic, creative and capable of facing the truth as it emerges from the objective study of reality: an individual able to comprehend fully the nature of technical and social change and having deep concern for the improvement of society.
4. Mobilizing the youth for leadership roles through participation in programmes of social service and environmental improvement, and by inculcating in them the dignity of labour.
5. Eradicating illiteracy within the shortest possible time through universalization of elementary education and a massive adult education programme.
6. Equalizing access to education through provision of special facilities for women, under-privileged groups and mentally retarded and physically handicapped children and adults in all areas in general and the backward areas in particular.
7. Designing curricula relevant to the nation's changing social and economic needs compatible with our basic ideology and providing a massive shift from general education to more purposeful agro-technical education.
8. Providing a comprehensive programme of studies through the integration of general and technical education and by keeping options open for transfer from one course of study to another.

9. Providing academic freedom and due autonomy to educational institutions within the framework of national objectives and equipment.
10. Ensuring active participation of teachers, students and representatives of parents and the community at large in educational affairs.
11. Generally promoting the welfare, dignity and sense of responsibility of teachers and students.

The People's Government decided to change education from an elite privilege to an equal expectation pronouncing that this opportunity would belong to every citizen regardless of race, religion or birth. On the one hand, the Government resolved to democratize education and usher in an era of universal literacy as soon as possible; on the other, it was conscious of the compelling need to compete in the race of higher science and technology in a world which was moving very fast towards post-industrialization. It was therefore resolved to embark upon a massive shift from aimless general education to a more meaningful agro-technical education. It was considered essential that a boy who dropped out of school after grade VIII should carry with him enough skill to return to his local or ancestral vocation as a better farmer or craftsman and that a boy who left school after matriculation (grade X) should be ready to be absorbed in the socio-economic framework of the country as a good middle-class technician or worker. On this basis, the policy was adopted of catering for all those who would leave school to enter social responsibility. Further, it was decided that while expanding education, it must be related in its form and content to the nature and scope of the economic development of the country, and to employment opportunities.

Formal education in Pakistan is organized into five stages. It includes five years of primary education (grades I to V), three years of lower secondary and middle education (grades VI to VIII), two years of upper secondary and matriculation stage (IX and X), two years of intermediate general or technical education (XI–XII), from two to five years of higher education in college, university or equivalent professional courses, and from three to five years of post-graduate research studies. In primary and secondary education the provincial language and Urdu/English (in English-medium schools) are the languages of instruction. English is generally employed at the post-secondary level. Education is not compulsory.

At the certificate level, the vocational schools, whose present enrolment is 8,000, will be merged with the general educational system. Technical courses will be introduced very widely as part of the curricula for the secondary stage.

The diploma-level education, corresponding to a higher-secondary stage, is presently imparted by polytechnics. These institutions will be gradually improved and elevated to technical-college level and will provide (a) technical diplomas and (b) technical degrees. New technical colleges will be set up in areas where no polytechnic exists. The total enrolment in polytechnics/technical colleges is expected to rise from 12,000 in 1974–75 to 20,000 in 1979–80.

Science education at the first level

Pakistan introduced integrated science for grades I to V in 1974. This integrated science programme has been launched to promote science literacy, which means not only *knowing* but also *doing*. This programme aims at the total development of the personality of the learner through the involvement of the senses in the observation, exploration and understanding of the natural as well as man-made environments by means of open inquiry combined with experimentation.

This scheme is envisaged as a comprehensive integrated science programme for the age group of 5–13, based on Piaget's stages of the development of the child. Instead of the learning of 'facts', development of basic scientific concepts and principles in the context of their natural environments and applications of process has been emphasized–in short, the teaching of science and technology.

With the direction of the Education Policy (1972–80) in view, the National Bureau of Curriculum in collaboration with the Provincial Bureaux of Curriculum prepared a draft of the goals and aims of education in Pakistan, which was circulated for comments and criticism. After incorporating changes, the goals and aims of education were adopted. In the light of these, Provincial Bureaux were asked to prepare a draft scheme of studies in elementary science (I–V). The working drafts prepared by the Provincial Bureaux were then considered by the National Committee on Elementary Science and, after necessary modifications, were approved.

On similar lines, integrated science curricula for grades VI–VIII were also revised and introduced throughout Pakistan in 1975–1976.

Salient features of the programme:

1. Objectives are specific;
2. The programme is directed towards the learning of basic concepts and understanding their relationships rather than memorization;
3. The content presents integrated science programmes, and is divided into three major themes–(a) living things, (b) matter and energy, and (c) the earth and the universe;

4. These three major themes are then broken down into basic concepts which are easy for children to comprehend;
5. Each theme is developed horizontally and vertically, psychologically and chronologically;
6. Activities suggested are specific, and presented in a way that helps children understand concepts through their own experience.

Science education at the second level

At present about 70 per cent of students in secondary schools are enrolled in arts subjects. A large-scale shift from the enrolment in arts towards enrolment in science and technical subjects is underway. By 1980, one third of the total enrolment will be in each of the three main streams of Arts, Science and Technical/Occupational subjects.

An integrated science course, including mathematics and biological and physical sciences has been designed for secondary classes with a view to giving students a more comprehensive and wider choice at the time of entry into higher institutions of professional or general education. Initial work on the revision and development of the secondary and intermediate (grades IX–XII) stages of education has already started. Research studies and open seminars are being conducted on curriculum development. On the basis of these studies and seminars, the secondary teacher education curriculum is being revised and developed, keeping in view the discernable trends in secondary teacher education in the Asian region.

Instructional technology

Pakistan is faced with complex problems pertaining to the expansion and improvement of its educational programmes. Perhaps the most fundamental problem confronted by the country is the question of improving the standard of education. Our education system, as it exists at present, is characterized by heavy reliance on textbooks, lecture method, rote memorization and other similar practices which are considered least conducive to learning. Hence the graduates of our educational system tend to be weak in critical thinking and the ability for comprehension and application of knowledge to concrete situations of life.

To overcome this, the Education Policy (1972–80) has advanced very significant decisions. It is estimated that about 10 per cent of the decisions of this Policy pertain to the improvement of techniques of adoption of new media of instruction. Many other similar decisions of the Education Policy stress the use of instructional technology ranging from simple inexpensive audio-visual devices such as charts, models, graphs, picture exhibits and programmed materials, up to such modern technological instructional devices as radio and television.

In order to implement the instruction of the Education Policy it has been deemed essential to first provide training to the teacher trainers throughout the country. The Instructional Technology Unit of the Ministry of Education, in collaboration with the British Council, conducted three courses in audio-visual training in 1974 and 1975 at Lahore, Hyderabad and Peshawar. The courses were intended to provide basic training in the production and use of audio-visual materials to teacher trainers from all parts of the country. Through these courses about 120 key teacher trainers were trained in new techniques of audio-visual instruction.

Training of teachers and other educational personnel

The need for re-orientation/reconstruction of our teacher education curricula for all levels has long been felt. With the revision of the curricula for the primary and elementary stages and the proposed revision of the curricula for the secondary and higher-secondary stages which is now underway, the need for providing sound basic education and professional training to teachers has become all the more acute. The new curricula cannot be effectively implemented unless the entire teacher education curriculum is also revised so as to incorporate in it the new orientation, which has inspired the entire process of revision of curriculum in the country.

Pakistan is basically an agricultural country but its economy is shifting towards industry. To assist in this movement and maintain a balance between agricultural and industrial development, modern methods of agriculture and spread of industry without disrupting agricultural activity, agro-villages are being created to bridge the technological gap between rural and urban areas. Agricultural technology is also being developed to take the benefits of science and technology to the people.

The present Education Policy (1972–80) envisages the system of school education to be so designed that the knowledge and skills imparted would ensure that those benefiting from this education could be usefully absorbed into the economy of the local community. The economy of the country demands that the products coming out of schools/institutions be productive so that they will be no more a burden on the society but rather make a contribution in increasing the agricultural and industrial productivity. After leaving school they should be sufficiently developed to acquire skills to do useful work. The role of the elementary and secondary teachers is thus shifting from mere classroom teaching in subjects that were non-technical and did not demand from the teacher the expertise of skills of demonstration on actual jobs and participation with the students in such projects. The teachers in Pakistan now have to be trained accordingly, and as such all the teachers training institutions in the country are changing their curricula to suit the new role of the teacher. The huge number needed of such teachers has become difficult to achieve.

As a consequence of the massive shift to agro-technical studies a new category of teachers in agro-technical subjects has come about. In the whole of the country, the teaching of agro-technical subjects will be classified into three main categories: (1) Industrial Arts; (2) Agriculture; and (3) Home Economics.

In urban areas of Pakistan, 80 per cent of the schools would teach industrial arts whereas 20 per cent would undertake the teaching of agricultural subjects. In rural areas, 80 per cent of schools would undertake teaching in agricultural subjects and 20 per cent would be teaching industrial arts. Home economics would be taught in all the middle and high schools for girls.

In this changing pattern of elementary and secondary education, the role of the agro-technical teachers is going to be very significant in determining the success of such a challenging programme. The teacher would be required to break through the innate aversion to manual work in our society. The age-old inhibitions are to be ended and emphasis on skill training is to be restored. The agro-technical teacher has to be a skilled hand who will possess a special attitude and aptitude to work with the students in learning. To provide for this new role of agro-technical teachers, the curricula of the teacher training institutions in the country are being revised.

Keeping these pressing considerations in view, the Curriculum Wing undertook a comprehensive project to revise the teacher education curricula for all stages. As a first step, the teacher education curriculum for the elementary stage has been revised.

Current trends in science education

The Science Education Centre, Institute of Education and Research, Punjab University, Lahore, is organizing Science Education as follows:

1. Preparation of teaching kits
2. Preparation of instructional materials;
3. Open-ended experiments in physical and biological sciences;
4. Comparison of conventional methods of teaching science and enquiry-oriented teaching.

Science at the elementary stage has been introduced as an integrated course consisting of relevant matter for the main branches of science like biology, physics, chemistry, geology and astronomy. The subject matter has been divided into three broad content areas: living things, matter and energy, earth and universe. This grouping does not mean any rigid division of concepts but rather the concepts in all the three areas overlap and are repeated through a spiral approach at different levels.

A new scheme of studies for secondary grades IX–X provides an integrated science course including mathematics and biological and physical science, with a view to giving students a more comprehensive and diversified preparation enabling them to have a wider choice at the time of entry into higher institutions of professional or general education.

With this guideline in view, curricula for the two aforementioned levels have been revised and designed by the subject committee comprising subject expert curriculum planners, psychologists and working teachers. The distinguishing features of the new curricula are that they are process-oriented, enquiry-oriented, integrated, stress learning by doing and have a heavy vocational bias.

Instructional materials. The following teaching/learning materials have been produced:

1. Discovery experiments in physics for high school students (experimental edition).
2. Discovery experiments in chemistry (experimental edition).
3. Discovery experiments in biology (experimental edition).
4. Transparencies in biological sciences (200).
5. 35mm slides in physics and chemistry for high school students (100).

New instructional methodologies. A vast project has been prepared with the collaboration of Unicef to supply teaching kits to primary schools throughout the country to help them improve the quality of education and implement the new curricula. The project envisages the supply of kits to about 80,000 primary schools. Approximately 10,000 kits were produced during the first year for supply to schools. The project has been prepared in response to the general feeling that the quality of teaching in the country needs radical improvement, especially if the objectives of the Government's educational policy are to be achieved.

The kits are made from indigenous materials and include a variety of materials and equipment in all school subjects including Islamiat, science, mathematics, social studies and languages. Each kit is a self-sufficient package comprising all those elements which are needed to perform new experiments and activities in accordance with the new curricula. Along with the kits, a teacher's tool box containing basic tools and instruments is being supplied to schools to help the teachers to produce inexpensive instructional materials on their own.

Preparation of teachers. Post-graduate teacher training institutes in Pakistan offer seven different post-graduate degrees in the field of education: (1) M.A. Primary Education, (2) M.Ed. Primary Education, (3) M.A. Secondary Education, (4) M.Ed. Secondary Education, (5) M.Ed. Business Education, (6) M.Ed. Industrial Arts Education, and (7) Ph.D. in Education.

The M.A./M.Ed. Programme at the Institute of Education and Research, University of the Punjab, offers nine areas of specialization based on modern trends and needs of the country in accordance with the spirit of the Education Policy (1972–80): (1) Language Education, (2) Mathematics Education, (3) Science Education, (4) Social Studies Education, (5) Educational Psychology, (6) Educational Guidance, (7) Educational Administration, (8) Curriculum, and (9) Teacher Education.

At the Master's degree level, science education as an emphasis area has been introduced. The following courses in science education are offered: Physical Science I and II, Biological Science I and II, and (for non-science specialization only) Environmental Science and General Science. As to professional courses, there are:

1. Methods of Teaching Science
2. Advanced Methods of Teaching Science
3. Instructional Materials in Science
4. Discovery Laboratory–Techniques
5. Seminar in Science Education
6. Practicum in Science Education

Teaching practice is carried out through a course of from 8 to 12 weeks of Student Teaching. Research goes on simultaneously.

Utilization of community resources (including community problems) as learning resources. Problems of the community are the basis of curriculum modernization in Pakistan. The rationale for the introduction of agro-technical education is the utilization of community resources throughout the country.

Evaluation methods and procedures

With the introduction of the elementary science curriculum for grades I–III throughout the country in 1973, an evaluation programme was launched to test the validity of the concept grading and methodology. A sample testing programme was designed. The programme was given the name 'Micro-testing'.

The project was designed to investigate the relevance of content, methods and materials. Some schools were selected for the implementation of the project, both in rural and urban areas of the provinces. A committee of subject experts, curriculum planners and teachers was assigned the task of designing and supervising the programme of microtesting. The committee implemented the programme under the guidance of Provincial Bureaux of Curriculum and in collaboration with numerous teachers, headmasters and headmistresses of elementary schools.

Selection of concepts for microtesting. Some concepts were selected for testing which, in the opinion of curriculum committees, were rather difficult for grades I–III. These concepts were selected from all the content areas of the curriculum, by grade and by area.

Preparation of reading material. These concepts were grouped into units with respect to their interrelationships. The reading materials were prepared in the form of picture books. A teacher's guide book was prepared containing an introduction to the microtesting programme and methods for evaluation of children's understanding of concepts as well as a teaching kit containing charts and other teaching aids.

Orientation of teachers. One or two teachers from each school in which the evaluation programme is operating were given this course. A set of teaching materials was provided to each teacher. A questionnaire was developed for the evaluation of the programme to be filled in by the teacher at the end of each lesson. The questionnaires were collected from experimental schools and data was consolidated and analysed.

The science curriculum for grades I to V and VI–VIII are being put to use, and vocational science curriculum at the second level has been finalized and is soon to be implemented. Evaluation is also about to begin.

Characteristics of and developments in science education

1. Content is integrated with life situations and the environment.
2. Enquiry-oriented teaching is being experimented using inexpensive equipment produced from indigenous materials.
3. There is increasing use of audio-visual materials in schools.
4. The laboratory-oriented and integrated science programme is divided into three broad themes: open-ended, discovery-oriented techniques; experiments; and demonstration.
5. Curriculum revision is in line with modern developments, emphasizing the process of learning, the development of positive attitudes, mastery of skills, encouraging observations, exploration and experimentation based on the national needs.
6. Teachers' guides are available for science, mathematics, social studies and Urdu at the elementary level.
7. Teaching kits and teachers' laboratory manuals have been developed for elementary education.

8. Science Education Centre has been established at the Institute of Education and Research, University of the Punjab, for providing experience in open-ended discovery laboratory techniques and research in science education
9. A National Educational Equipment Centre has been opened at Lahore.

Problems in the expansion of science education

There are many problems, as may be seen from the list which follows.

1. Proper training in the production and use of low-cost audio-visual aids needs to be regarded as essential for every teacher.
2. There are problems of adjustment regarding educational changes, particularly for the teachers who join institutions of professional training after having put in long service as a teacher.
3. Teacher selection procedures need thorough overhauling. These should aim at measuring the academic strength, aptitude for the profession and desirable personality traits.
4. The service conditions of science teachers should be so improved as to keep their interest alive in the profession.
5. The traditional practices followed by the training institutions should be critically examined to judge their relevance and efficiency.
6. Defective methods of examination do not give a true picture of the student teacher's achievement and aptitudes.
7. Teachers have a lukewarm attitude to curriculum innovation and demonstrate considerable resistance to change.
8. In-service training programmes need to be organized more systematically, keeping in view the basic philosophy and objectives underlying the programmes.
9. The number of professional books in the libraries of the training schools/colleges/Departments of Education is inadequate.
10. The training schools/colleges ought to be residential so that the teacher educators may observe activities of the pupil-teachers.
11. Changes are needed in the goals and objectives of science teaching to align them with current thinking in both science and education.
12. The kind of instruction needed for science teachers to enable them to develop competencies required for achieving the desired goals and objectives needs consideration.
13. Greater emphasis should be placed on laboratory and field work.
14. More knowledge is required about the nature and dynamics of learning.

15. There is need to motivate the owners of industries/farms to co-operate in school education in allowing the learning to be carried out in actual productive situations.
16. Physical facilities at the elementary stage are very poor. Most of the schools do not have buildings of their own and have unsatisfactory and temporary accommodation, supplied by local communities; in such situations the establishment of science labs and demonstration rooms is difficult.
17. Most of the teacher training colleges and institutions are poorly equipped. Such equipment which they do have is of the classical type and obsolete.
18. Because of the overcrowding in classrooms, personal attention to the students is not possible.

Future plans for science education

The intelligent method of introducing innovation is through experimentation. It is never safe to adopt, without question, the innovation or programme of other countries unless its feasibility has been explored. Thus there is a need for centres with facilities of research in science (and technology) education for guiding and projecting the future planning and implementation of curriculum innovations and experimentation in open-ended and discovery laboratory techniques. It is suggested that a network of science and technological education centres be established in all the provinces in line with the one in the Punjab University (which should be developed to have agro-technical workshops and science curriculum laboratories).

These centres established at the Universities of the Punjab, Sind, Baluchistan and N.W.F.P. will act as centres for action research in curriculum developments, methods and techniques of science and agro-technical teaching, and will provide first-hand, open-ended laboratory experiences to in-service and pre-service science teachers and teacher educators.

In order to co-ordinate activities pertaining to curriculum innovation and research in the methods of teaching science and agro-technical studies, it is suggested that National Centres for Science Education and Technological Education be established by the Curriculum Wing of the Ministry of Education. These centres at Federal level should act as 'nerve-centres' for action research in curriculum development and methods of teaching science and technology including the discovery type of experimentation to improve the quality of science education in the country. The centres have been conceived to implement the decisions in the Education Policy pertaining to the universalization of elementary (primary) education and the major shift towards technology and integrated science programmes.

The centres will also act as nuclei for the science and technological education reforms which are being launched in the country and as clearing houses for exchanging recent science and technological curriculum materials developed in Pakistan and in other countries. It is through such a network that the introduction of innovations and new techniques will be expeditiously implemented after experimentation and testing to bring about new approaches to science education. Other proposed future activities are the following.

1. The organization of seminars/workshops on new dimensions in science education at the Curriculum Wing, Ministry of Education, Islamabad.
2. Training or re-training of 2,200 master teacher trainers in science at the National Institute of Teacher Education.
3. The organization of special projects on science education, if possible with assistance from Unesco.

A SCIENCE EDUCATION PROJECT

Objectives

This project started in June 1971 at the Institute of Education and Research in Lahore, and was designed to improve and modernize teacher training laboratories in Pakistan.

The overall project purpose is to set up a model Science Education Centre as a pioneer resource centre with modern facilities for laboratories in physical science and the biological sciences for teachers and specialists. The centre is intended to act as a nucleus for the dissemination of information regarding experimental testing and development of promising new ideas for improving instruction in science and the development of supplementary teaching aids to increase the effectiveness of instruction.

To do this, the project co-ordinator intends to:

a) Develop special laboratories for training physical science and biological science teachers;

b) Set up science curriculum laboratories;

c) Carry out enquiry-based experiments and demonstrations; and

d) Produce teachers' guides, student workbooks, transparencies, film strips and film slides in physics, chemistry and biology for grades I to XII.

Project implementation and evaluation

A special teacher training programme with science education as the emphasis area was introduced in the Institute of Education and Research in September 1971. Science teachers are being trained here both in the content and pedagogy.

Materials are being tried out on final-year students in Master of Education degree courses (teachers with at least three years' teaching experience) during their terminal activity known as *Practicum* at the institute, as well as at the Education Extension Centre in Lahore.

The effectiveness of the materials is so far being evaluated internally. A comprehensive questionnaire was distributed to 27 teachers who participated in a preliminary try-out from Punjab province. Of these, 60 per cent responded completely, 20 per cent responded partially and 20 per cent did not respond at all. Fifty-six per cent of the respondents were in favour of the discovery-type experiments as given in the experimental edition of the book *Discovery experiments in physics/chemistry.* The reasons cited for their preference were that discovery experiments develop interest and curiosity and provoke the imagination. These experiments develop an ability to use science in everyday life and encourage students to work for themselves. Nineteen per cent of the respondents also liked these experiments because they were intrinsically of interest, while 25 per cent did not favour them because they felt that in the existing system of examinations in Pakistan the additional time required for such experiments would not permit these practicals to be conducted properly in the schools.

Progress of the project. Science activities for children of grades I to V in accordance with the modernized science syllabuses produced by the Ministry of Education have been developed. A science teaching kit for pupils was prepared. The production of teaching materials including laboratory kits (enquiry type) is also in progress.

Future plans. The planning and developing of science activities for pupils of grades VI–VIII is to be carried out. Experimental study on the comparison of open-ended experiments versus conventional experiments in selected schools of the Punjab is also about to begin.

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THE PHILIPPINES

Present state of science education

The Philippines has a ten-year system of education—a six-year elementary level and a four-year secondary level. Generally, four or six years of schooling is free; a few cities provide free secondary school education. Pre-school education is mostly in the hands of the private sector and is available only for those who can pay the tuition. Post-secondary education may be academic or technical/vocational. Post-secondary technical programmes are generally two-year courses in the formal system. Most academic degree programmes require either four or five years of formal schooling, except for law which takes eight years and medicine which takes nine years. Currently, proposals to shorten medical education are being considered. The structure of the formal education system is shown in Figure 1.

Four national curriculum development centers for elementary and secondary curricula have been identified: one each for science and mathematics, social studies, language and practical arts. The University of the Philippines Science Education Center (UPSEC) has been designated to develop materials in science and mathematics. Planning of curriculum materials and projects is done by the staff of this center within the policies set by the National Board of Education and the Department of Education and Culture (DEC).

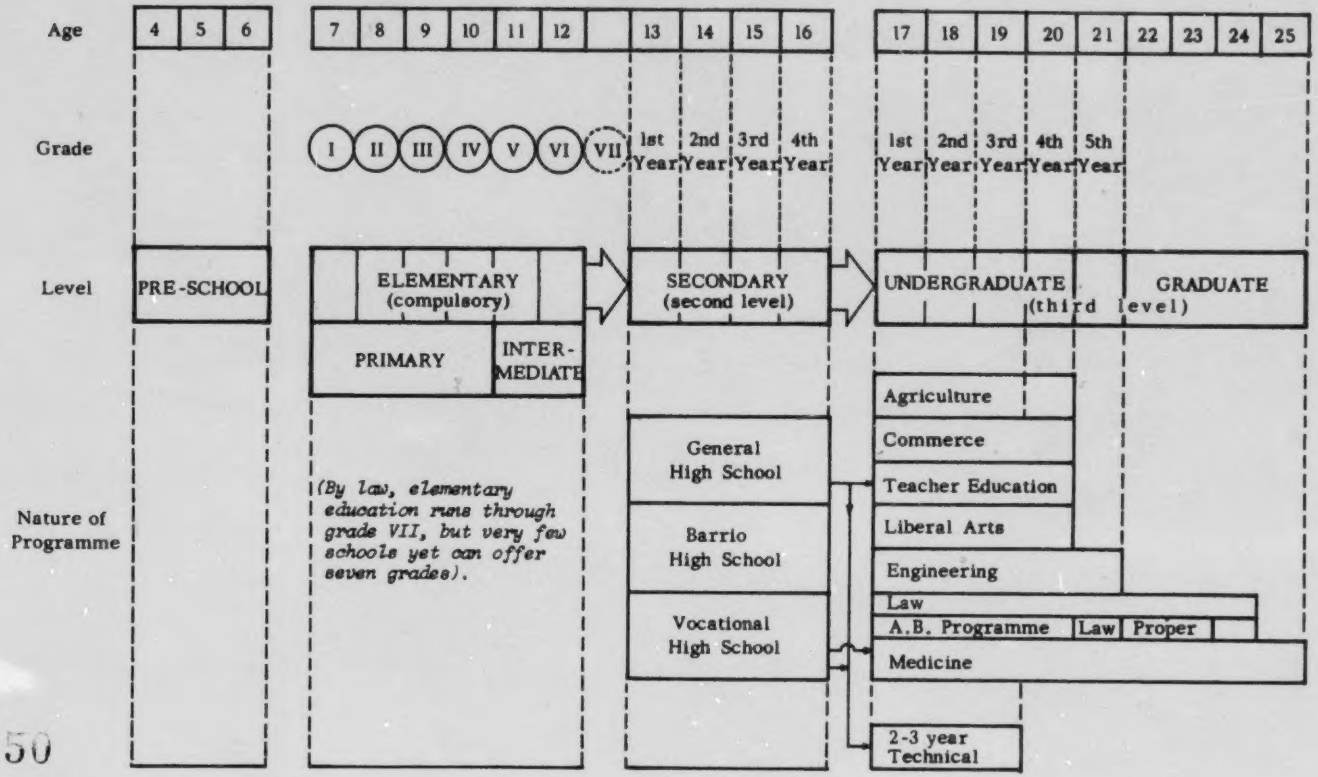
Within the Department of Education and Culture, the Bureaux of Elementary and Secondary Education each have a curriculum unit which plans for specific subject areas in co-ordination with the Planning Services Division. A proposed curriculum co-ordinating unit in the Planning Services Division will co-ordinate curriculum projects and activities of the DEC units and the national centers.

Overall planning for technology education at the national level is carried out by the National Manpower Youth Council. A paradigm for identifying areas of concern for the country's manpower plan is shown in Figure 2, on page 130.

Science education at the first level

Science and health education, which are generally taught together in the first three years of the elementary level, provide broad and basic

FIGURE 1. STRUCTURE OF THE FORMAL SYSTEM OF EDUCATION OF THE PHILIPPINES, 1973


Age
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24
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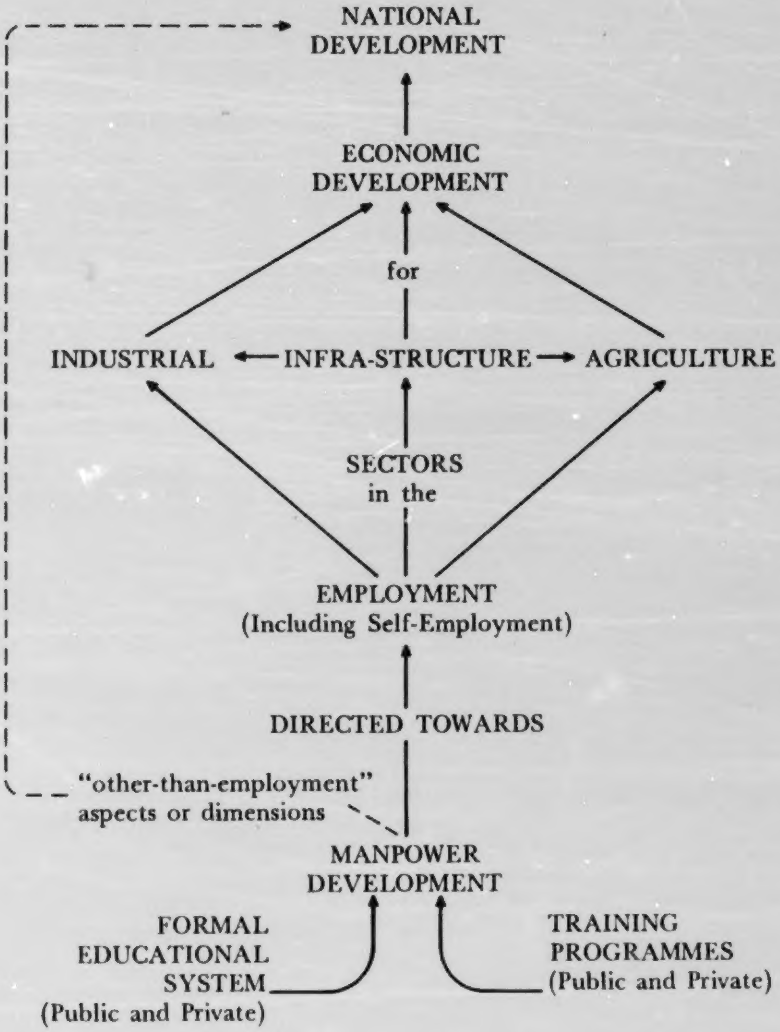
Grade
I
II
III
IV
V
VI
VII
1st Year
2nd Year
3rd Year
4th Year
1st Year
2nd Year
3rd Year
4th Year
5th Year
Level
PRE-SCHOOL
ELEMENTARY (compulsory)
SECONDARY (second level)
UNDERGRADUATE
GRADUATE
(third level)
PRIMARY
INTER-MEDIATE
Nature of Programme
General High School
Barrio High School
Vocational High School
Agriculture
Commerce
Teacher Education
Liberal Arts
Engineering
Law
A.B. Programme
Law
Proper
Medicine
2-3 year Technical

(By law, elementary education runs through grade VII, but very few schools yet can offer seven grades).

science and health knowledge and skills which lend continuity and sequence. Science is taught as a separate subject from grades IV to VI. About 30 minutes is spent daily on this subject throughout the school year.

FIGURE 2. PARADIGM FOR IDENTIFYING AREAS OF CONCERN FOR THE INTERIM MANPOWER PLAN


NATIONAL DEVELOPMENT
ECONOMIC DEVELOPMENT
for
INDUSTRIAL
INFRA-STRUCTURE
AGRICULTURE
SECTORS in the
EMPLOYMENT (Including Self-Employment)
DIRECTED TOWARDS
"other-than-employment" aspects or dimensions
MANPOWER DEVELOPMENT
FORMAL EDUCATIONAL SYSTEM (Public and Private)
TRAINING PROGRAMMES (Public and Private)

Significant characteristics of the science education curriculum are: (1) emphasis on the teaching of basic concepts in the biological and physical sciences, with topics selected from the broad areas of living things, matter, energy, motion, earth and space; (2) emphasis on the teaching of science processes and problem-solving skill; (3) pupil- and activity-oriented learning; (4) environment-oriented learning; (5) incorporation of concepts from population education and conservation at appropriate points in the science curriculum. A number of schools at this level (both public and private) are currently trying out individualized instructional programmes.

Science education at the second level

The science curricula offered at the second level may be described briefly as follows: "The natural sciences (biological and physical) consist of integrated science courses with emphasis on a particular area at each year level. Science I (first year) emphasizes physical concepts. Science II (second year) emphasizes biological concepts. Science III (third year) Chemistry and Science IV (fourth year) physics. These courses aim to strengthen the science processes developed in the elementary grades and to acquire basic knowledge of scientific concepts and principles making the student scientifically literate and therefore a more effective citizen." [1]

During the first two years of the secondary level science is given three hours per week; in the third and fourth years it is given five hours per week throughout the school year. The science courses from the first to the fourth year of the technical stream are similar to those offered in the general curriculum, except that the practical aspects are emphasized.

Science education in out-of-school programmes

Science education for out-of-school youth is still in its infancy. There are some science-related materials on health and nutrition and in population education available for the public through the agencies concerned with these problems. There are also a few current curriculum development projects responding to the need for out-of-school education.[2]

Self-learning kits developed for the 'In-School—Off-School Approach' by the DEC staff to implement an approach which is designed to effect optimum utilization of community resources might conceivably be extended to out-of-school youth. This aspect, however, has not yet been tried.

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1. Department of Education and Culture. *The Revised Secondary Education Program,* 1973.

2. Two of these are being conducted by UPSEC: (1) Science Principles in Agricultural Practices, and (2) The Role of Parents and the Community in Science Education Development.

On the side of technology education, however, massive plans are being put into operation by the National Vocational Preparation Programme for youth between 12 and 17 years of age. This programme is being developed in three major directions: agriculture, cottage industry and industrial skills. Under agricultural skills are included, among others, rice and corn production, animal husbandry, food preservation, and fisheries. Cottage industry includes bamboocraft, woodworking, ceramics, fibercrafts and textiles. Industrial skills include: repair and maintenance of farm implements, building construction, automotives, and electrical trades.

Organization and institutional arrangements

At the national level, the National Economic and Development Authority (NEDA) plans with the assistance of the agencies concerned such as the National Science Development Board, institutions of higher learning, Department of Education and Culture particularly in the area of science and technology and their roles in national development. A recent workshop was held to determine "linkages between science and technology and socio-economic planning needs based on sectoral planning objectives and strategies, existing R and D projects and their relevance and acceptability to end users".[3] Education (science and technology) was one of the areas which was discussed in this workshop.

In the Department of Education and Culture, the newly organized Bureau of Elementary Education sets, formulates, and develops educational policies and programmes with respect to the first level of education. It has a curriculum development division which undertakes curriculum designs including materials preparation (in all subject areas). The Bureau of Secondary Education has similar responsibilities and will also have a curriculum development division with similar functions. Co-ordination of curriculum development is effected through the Department of Education and Culture.

Instructional materials

One source of textbooks in the country is the national curriculum development centers whose books are automatically adopted by the Textbook Board for use in the schools. There are other sources–private publishing companies for example may hire writers to prepare manuscripts in response to a call issued by the Textbook Board for a particular subject and grade level. Manuscripts thus produced will have to follow development procedures similar to those used by the Centers; i.e., a manuscript that has been preliminarily approved by the Textbook Board will have to be field-tested and then revised based on the feedback from the evaluation. Only after a manuscript has gone through this procedure can it be considered for final approval.

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[3] "Science and Technology in Education Planning", NEDA, August 1975.

The price of textbooks is set by a Price Committee of the Department of Education and Culture. This Committee is composed of some members of the Textbook Board, and a representative each of the Philippines Government Printing Office and the Philippine Educational Publishers Association.

For the public schools the Textbook Production Service of the Department of Education and Culture supervises the production and distribution of the textbooks in a manner determined by the Textbook Board. This service unit maintains an up-to-date inventory of textbooks actually procured and distributed to the schools. On the basis of such inventory, the Textbook Board determines the textbook requirements of the different parts of the country and books are allocated accordingly.

The students in public schools are generally provided with free textbooks, particularly at the elementary level. They may pay a nominal amount (a rental fee) at the secondary level. The private schools are enjoined to use as much as possible the books approved by the Textbook Board. The private school students generally buy their own books.

With regard to equipment, there are only a handful of equipment supply houses that currently manufacture school equipment locally. The National Science Development Board (NSDB) with UNDP assistance has recently started an equipment development project which aims to develop equipment closely associated with the Science Education Center's curriculum materials. This project will develop equipment to the level where they can be mass-produced.

Training of teachers, research and evaluation

Teachers for the first level of education are trained in teacher training institutions or colleges of education. All earn a bachelor's degree in elementary education. Teachers for the second level of education earn a Bachelor of Science in Education degree (B.S.E.) with a major/minor in a science subject area. They obtain their degree from colleges of education in a university or a teacher training institution.

In-service programmes for science teachers are conducted by the DEC as special institutes during the summer and sometimes during the academic year. A system for reaching the more deprived areas of the country has been initiated so that in-service education programmes will soon reach the teachers in the small and remote towns and barrios. This in-service programme, which is an outgrowth of an earlier and existing project, is monitored by the Educational Development Implementing Task Force (EDPITAF) and the NSDB. EDPITAF has established a network of Regional Staff Development Centers (RSDCs) throughout the country. Teachers are trained in special institutes in these centers in specific subject areas (e.g., science and math). The trained teachers in turn are to conduct seminars for schools in their locality. This multiplying effect is implemented mainly through a system of development high schools and decentralized resource centers (selected elementary schools). These schools serve as demonstration and dissemination centers and serve their local communities with technical assistance from the RSDCs. These schools will be strengthened in terms of equipment, books and trained staff. Eventually, all subjects in the curricula including technical courses will be included in this programme.

Most of the leading curriculum development projects in the Philippines have built-in evaluation programmes. This is mostly formative evaluation intended to secure feedback from students/teachers using new curricula in order to improve these curricula. Some evaluation studies on summer institute programmes have been conducted. A few of these have been quite extensive and have included studies of the effect of programmes in student performance. Studies on attitudes have also been conducted.

Research in science education has tended to be of the descriptive type related to the curriculum, teaching and the learning environment. Some studies have focused on the substantive aspects–practical studies which shed light on facts in the natural environment which are needed for the preparation of curriculum materials. Studies of the experimental and of the philosophical type are among the most neglected.

Trends in science education

Curriculum development and learning materials. Early efforts in curriculum development tended to be adaptations of curriculum development projects abroad. With experience gained in the early projects and with data collected from the tryouts of such materials, the revised and new materials tend to incorporate more local materials, and are more oriented to the demands of the educational system. Greater effort seems to be made to gear the new materials to the environment of the Filipino child who lives in the rural and deprived areas today than in earlier projects.

Stress is now being given to the development of science equipment indigenous to Philippine localities. The NSDB is now undertaking an equipment development project which will provide the hardware for the software already produced locally. With this project it is expected that science education programme will soon be able to solve, even if only partially, the perennial problem—that of school science equipment.

With regard to textual materials for science and mathematics, preparations have become institutionalized with the identification of national centers to conduct these activities. In addition to textbooks, modules of several types are now being prepared; these may be topical, self-instructional, programmed materials, and the like.

In both public and private schools, individualized instruction, continuous progress education, mastery learning and the use of self-learning kits are currently being tried out in various schools. In some schools one or two of these have become established as the major instructional methodology currently used at both first and second levels.

The objective of most of the new instructional methodologies is to enhance learning. It is not so certain that this notion is appreciated, especially when innovations are introduced on a larger scale, before the materials which exemplify the methodology—and the teachers—are prepared for the innovation.

On the inter-relationships between science education and technology education a good beginning has been made through the efforts of NEDA, NSDB and EDPITAF. Workshops and meetings conducted by these agencies encourage interaction among the curriculum development centers and other national agencies.

Teacher preparation. The preparation of teachers remains quite unchanged: innovations have not been made except in a few courses. There are plans to have a common curriculum for both secondary and elementary teachers instead of having separate degree programmes as currently required. But even with such a plan, the innovation seems to be mainly in terms of rearranging existing courses and number of units to be earned. The existing basic patterns of degree programmes remain unaltered.

The in-service programmes have responded more quickly to teachers' needs and problems in the field. The science education project of the Philippines has a well-established network of centers and schools which attend to teacher education needs. The DEC regularly conducts seminars and workshops for teachers.

Utilization of community resources. Maximum utilization of community resources is a major element in the "In-school, off-school approach" which is currently being tried out by the DEC in selected communities. In this approach, students stay in school one week to undertake the education activities normally included in school practice. The next week they spend out of school and learn from kits which are sequenced self-learning tasks and are community based. They invariably require the learner to seek varied specified resources in the community.

The Science Education Center through some of the modules it is preparing has initiated some projects which are community related. Since most communities are agricultural, UPSEC has started a project on science principles in agricultural practices. Two such modules have been completed. It has also begun, with Unicef funding, a project which investigates activities of adults in a rural community as a basis on which to develop science education materials for adults and out-of-school youth.

Evaluation methods. With regard to evaluation, all national curriculum development centers utilize formative evaluation to secure feedback on the curriculum materials they prepare. These usually include teachers' and students' feedback, observation of classes and achievement tests.

Structural and institutional organization. The trend is toward regionalization of efforts, particularly the implementation of programmes in order to reach the remotest communities. The DEC has 12 regional education offices. Each has its divisions of elementary and secondary education. These divisions have charge of the curriculum of the schools in the respective regions.

The education development projects for science and technology education are also regionalized. The network for improvement of science education currently includes nine Regional Staff Development Centers (RSDCs), some development high schools and several decentralized resource centers (elementary school level).

In addition to the Regional Manpower Development Centers, the National Manpower and Youth Council has also established a National Vocational Preparation Programme for out-of-school youth between the ages of 12 and 17. The long-range objective of this programme is to establish a system of vocational preparation in 60 provinces and 20 city/municipal centers. Its more immediate objectives are: (1) to evolve a more comprehensive plan for vocational preparation, (2) to adopt a suitable set of curricula that are practical and meaningful to out-of-school youth trainees and (3) establish a highly trained corps of instructors.

Identification of problems

In science education, a major problem area is the constant maintenance of good instruction in science education particularly at the pre-service level and pre-university levels and the steady and keen responsiveness to local needs and problems in keeping with the national and world situations. Lack of good and up-to-date science books, equipment and space in which students can learn science through active personal involvement are among the major problems. Lack of research in various related areas, as well as in the area of science education itself is another problem. The reforms currently being undertaken are designed to meet these problems at all levels.

On the basis of the 1970 census, out-of-school youth constitute one third of the total of national unemployed persons, whose ages range from 10–19 years old; out of every three unemployed, one was an out-of-school youth. Training programmes to suit varying capabilities and interests of this group, at the same time filling manpower requirements of the country, need to be provided.

Future plans

Experience culled from the early stages of the science education programme of the Philippines has shown that what has been done so far is too small to create any significant change in elementary schools science education. Hence, stress is being given to this level of education in plans for the near future. Also, five additional regional science teaching centers will become operational in 1977 along with 33 strengthened development high schools and 56 decentralized service schools to serve the various regions at the grass-roots level. Strong efforts are being made to gear the programmes to national development goals. Other aspects being emphasized in future plans are: work-orientation and practical aspects of the curriculum, and equipment development and production closely related to the new curriculum–and intended to extend the outreach of science education to rural and deprived areas and to minority communities.

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SELECTED SCIENCE EDUCATION PROJECTS

Development and Production of Textbooks and Other Instructional Materials

Background. The dismal textbook situation is dramatically illustrated in a study undertaken in 1974 by the Textbook Production Service, then under the Bureau of Public Schools. It disclosed that the writing book-to-pupil ratio in each subject area averaged 1:10 in the primary grades, 1:12 in the intermediate and 1:9 in the high schools. Moreover, 79 per cent of the textbooks were already in classroom use for five to ten years—excluding the development and production time which has averaged eight years in the past.

The poor quality of textbooks currently in use is made very revealing by the results of the evaluation of elementary and secondary textbooks in public and private schools initiated by the Educational Development Projects Implementing Task Force (EDPITAF) in March 1974. Of the textbooks evaluated, 67 per cent were recommended for revisions and 33 per cent for replacement; not a single book was favourably endorsed.

Also, recent educational policies like those of the 'Bilingual Education' and the 'Revised Secondary Curriculum' call for major revisions to existing books or in most cases, the preparation of entirely new sets of textbooks.

General objectives. The proposed project addresses itself to improving the quality of basic education through the provision of good and adequate textbooks and by simultaneously bringing reforms to a wide range of policies and administrative practices which relate to textbooks.

Specific objectives.

a) To ensure the entire school system of well-researched and well-tested instructional materials;

b) To provide the lowest feasible textbook-student ratio for all grades in the elementary and high school levels;

c) To form a basis of any policy designed to make uniform the standards for adoption of a common basal textbook, with provisions in terms of enrichment or supplementary materials to respond to the unique or special needs of various sectors and regions; and

d) To serve as the basis for a continuing textbook development programme, i.e., preparation, trial and revision, printing and distribution, with a built-in mechanism for feedback and evaluation.

Project design. The objective of improving basic education is to be pursued as follows:

a) Organizing a composite of existing curriculum development centers (CDCs) into national research and development, textbook preparation and staff development for basic education. There will be five of these centers for specific areas of the curriculum. These are:

(1) U.P. Science Education Center–Sciences/Mathematics;
(2) Social Studies Center–Social Studies;
(3) Philippine Normal College–Language Arts, Language Study Centre;
(4) Philippine College of Arts and Trades–Practical Arts (Business/Industrial Arts);
(5) Central Luzon State University–Practical Arts (Agro-Fishery and Home Arts).

b) Establishing a network of Regional Staff Development Centers (RSDCs) which shall primarily serve as continuing education centers for teachers.

c) Selection of 56 elementary schools and 34 high schools to serve as try-out settings for textbooks and other materials produced by the CDCs and as dissemination and resource centers at the school level.

d) Creation of a Basic Education Development Council which shall monitor and co-ordinate the entire project activity, assisted by its regional counterpart in each of the 12 regions.

The following activities are envisioned for the projects:

a) The institutionalization of writing and developing research-based textbooks and their continuous evaluation. This will involve the participation of the five CDCs in the writing/development, including try-out of at least 40 separate textbooks with an almost equal number of teachers' guides as follows: 10 in Social Studies and 30 in Communication Arts (English and Pilipino). The

Science and Maths books have been developed by UPSEC and will be undergoing field testing and revision on a staggered schedule.

b) The printing and distribution of a total of at least 58.8 million textbooks spanning a total of five years from the School Year 1976–77 and ending in 1980–81. This will supply 50 per cent of the total book requirements.

Project development. The writing/developmental phase of the textbooks is a co-operative endeavour of varied specialists, particularly in the field of science. It will be undertaken by a core of subject specialists, methodologists and teachers from the field to ensure that the materials are appropriate for the levels in which they are introduced.

The books then undergo field testing for one school year to evaluate their relevance and effectiveness. Prior to the actual testing, co-ordinators (usually connected in the RSDCs) undergo training on the testing programme design and procedures for several days. The co-ordinators then conduct their own training with the experimental teachers, most of whom will be coming from the identified DRCs. The co-ordinators will transmit processed feedback results to the center after obtaining them from the experimental teachers.

When books are ready for the final edition, a massive teacher-training programme will be undertaken to enhance their competencies and train them in the use of the new textbooks, teachers' guides and other materials produced by the Centers.

Project implementation. The Basic Education Development Council (BEDECCO) is the proposed integrating body for all curriculum development activities affecting basic education. The Council is to stimulate, monitor and integrate the activities and outputs of the CDCs, the RSDCs, and the 34 development high schools and the 56 elementary resource centers into one unified programme of reform of basic education. To be chaired by the Secretary of Education, the council is to consist of the Textbook Board Chairman, the heads of various CDCs, the relevant units in the DEC, notably Bureaux of Elementary and Secondary Education and the Office of the Planning Services, EDPITAF Executive Director, DEC Regional Director representative plus two members from the private sector. Regional counterparts of the Council shall also be set up. The Textbook Board will determine the policies and guidelines in the development, approval, pricing and distribution of textbooks for use in public elementary and secondary schools. To provide technical assistance to the Board will be the Textbook Production Service (TPS) in co-ordination with EDPITAF (at least for the interim stage of the project) for the production and distribution aspects.

Problems, successes and future plans. One problem so far has been the vehement opposition of publishing companies to the provision in Presidential Decree 687 extending the automatic adoption of books developed by the Curriculum Development Centers for fear that their publishing business will be jeopardized. Their fears have been allayed with the government assurance of their rightful role (as publishers) within the system of free enterprise, subject to the new rules on selection and approval of manuscripts.

The distribution of books is far from ideal, with two main problems: the lack of storage facilities at the division offices and lack of financial provisions for hauling and delivery. EDPITAF is currently reorganizing the distribution.

The passage of Presidential Decree 687 amending the Textbook Law and "Providing the Guidelines in the Selection, Approval, Printing and Distribution of Suitable Textbooks for Use in Public Elementary and Secondary Schools" can be regarded as an initial success.

Also, the leadership and co-operative efforts that the CDCs, RSDCs and other institutions involved in the project have been demonstrating in initiating and implementing this endeavour have been very gratifying.

The project is to last five years, to the school year 1980–1981. Its objective is to provide a 1:2 book-to-pupil ratio for all grades in the first two levels. It is hoped that the country will eventually reach the ideal ratio of one book per pupil in each of the subject areas of the curriculum. It is also hoped that experiments in alternative teaching/learning practices, with the use of other instructional materials like audio-visual aids and modules to supplement textbooks can be initiated.

Establishment of Regional Staff Development Centers

Objectives of the project. The project originated from the experience of the Regional Science Teaching Centers (RSTC) which were successful as dissemination centers for the Science Education Project of the Philippines. The RSTCs, having been chosen to be regional centers for Social Studies and Communication Arts as well, will now be referred to as Regional Staff Development Centers.

The objectives are:

a) To serve as testing/adaptation centers for new materials and programmes, developed at the national level;

b) To serve as training and retraining grounds for teachers and school officials;

c) To serve as educational resource centers in the region, where both software and hardware inputs to classroom instruction and management may be found;

d) To serve as prototypes in the offering of a more balanced and better-synchronized teacher pre-service and in-service education.

Project design. The major components of the project are buildings, equipment, books and furniture. Of the 14 RSDCs only the RSDC at Palawan will be provided with complete facilities; i.e., building, equipment and furniture. The rest of the RSDCs will be provided with equipment, books and furniture to improve and expand their present physical facilities so that requirements for activities in social studies, communication arts and science/mathematics shall be accommodated.

Project development. There are two types of staff development programmes: those intended for the upgrading of the RSDC staff and supervised and co-ordinated by the various Curriculum Development Centers; and those for teachers within the service areas of the respective centers and held at the RSDCs or the Development High Schools (for secondary basic training) and at the Decentralized Resource Centers (for elementary basic).

The first may be degree- or non-degree programmes. For science and mathematics, under the sponsorship of the NSDB and the UPSEC, scholarships are provided for Master of Arts in Teaching, both in elementary Science and Maths and secondary Science/Maths.

In addition, degree- and non-degree programmes in language arts are offered at the Philippine Normal School. While the Social Studies Center is not a degree-granting unit, it works closely with the UP College of Education which offers master's and doctoral programmes in social studies.

The programmes for teachers may be six-week summer institutes conducted at the RSDCs, and with the objectives of strengthening and modernizing the teaching of elementary and secondary social studies, language arts, science/maths in the Philippine schools through the retraining of the teachers. Other programmes are for a week or a weekend.

To reinforce the training programmes for teachers, the administrators of participating schools are invited to attend the last few days of each seminar. This helps the principals, supervisors and superintendents understand the project better and become aware of their role in the national endeavour.

During the regular school year, the RSDCs are expected to provide high quality pre-service programmes by making available to students modern curriculum materials and teaching aids.

Project implementation. The RSDCs operate within an existing college or university. As a rule, the local autonomy of the co-operating institutions is respected and local initiative is encouraged. Hence, variations in the internal management of each RSDC will be present.

The various agencies in the development of the project are:

a) 5 Curriculum Development Centers;
b) 14 Regional Staff Development Centers;
c) 34 Development High Schools; and
d) 56 Decentralized Resource Centers.

All of these components are co-ordinated at the national level by the Basic Education Development Co-ordinating Council (BDECCO) and the various working committees by subject area.

Bureau of Secondary Education Faculty Development Programme

Background. This project was started in 1969 as the result of a research study which showed that most of the faculties, supervisors and administrators of vocational schools have not had training for the last ten years since 1965.

The objectives of the project are:

a) To increase the competencies of faculties and supervisors in science and mathematics in conjunction with vocational-industrial courses (machine shop, electrical shop, metal shop, wood-working, drafting);
b) To improve the competencies of supervisors and administrators through professional education courses.

The project offers degree courses in a graduate programme, including on-the-job training for the vocational teachers. Students' evaluation of the professors is given much weight.

Project implementation. The teachers on the programme have been chosen from outstanding personnel both in the government and private sectors. Classes are held on Saturdays and in the late afternoon of working days. The teachers are paid on contract.

The project is a joint venture of schools in the field—particularly vocational schools—the Bureau of Vocational Education (now part of the Bureau of Secondary Education) and the Center itself, the Marikina School of Arts and Trades. Most of the grantees have changed attitudes and views by becoming flexible and understanding, improved their performance and, consequently, been promoted.

The project is to last to the 1983–1984 school year. It is now a part of the Staff Development Division of the Bureau of Secondary Education so it is partly subsidized by funds from the Bureau. The physical facilities are those of the Marikina School of Arts and Trades, including new science equipment donated by the National Science Development Board.

It is proposed by the project co-ordinator to make the Center an experimental station for new ideas in education as well as the center for staff development.

Preparation of Curriculum Guides in Science and Mathematics

Background. This programme was started in 1974 and was designed to meet the needs of 13 experimental agricultural high schools which are implementing a curriculum in terms of curriculum materials for the use of mathematics and science teachers in these schools.

The objectives are:

1. To prepare curriculum guides in secondary science and mathematics for the experimental agricultural high schools;
2. To orient participants in newer techniques and strategies in teaching science and mathematics;
3. To develop skill in the preparation of better tests to measure student achievement in these subject areas.

A summer institute for science and mathematics teachers took care of the training of personnel who were to try out the teaching guides. An evaluation questionnaire is being used to determine the effectiveness of the guides. Plans are underway for writing textbooks based on the revised teaching guides.

Elementary Mathematics Curriculum Development Project

Background. The problems that the project was designed to meet were (1) the deteriorating elementary pupils' achievement in arithmetic revealed by research studies, (2) teachers' lack of interest and competence in teaching arithmetic, and (3) the inability of available instructional materials to help develop mathematical skills and understanding in the school population.

Objectives of the project. The objectives are identical with those of the curriculum materials developed. Fundamentally they are:

1. To create in the elementary school pupils an interest in mathematics by offering them exciting and challenging activities;
2. To develop in the pupils basic learning in the different areas of elementary school mathematics that will be permanent and functional;
3. To develop in the pupils a genuine understanding and appreciation of numbers and of the structure of numerical systems; and
4. To help pupils acquire skill in computation and problem solving.

Complementarily, the project aims to improve the professional and academic competence of the teachers and supervisors of elementary school mathematics.

Project design and implementation. The elementary mathematics improvement project consisted of two interrelated elements—preparation of new curriculum guides, and in-service training of supervisors, school administrators and teachers in mathematics. It followed a developmental approach consisting of (a) a preparation of tryout curriculum guides for teachers' use, followed by (b) a tryout of the curriculum guides by selected teachers in selected school divisions who sent evaluation feedback on the guides, (c) in-service training institutes for mathematics teachers in preparation for implementation of the new curriculum (d) revision and finalization of the teachers' curriculum guides based on the feedback of the tryout teachers and on studies on the guides by the writing groups themselves and (e) implementation of the new curriculum.

The implementation of the new elementary mathematics programme was laid primarily on the division mathematics supervisors in order to allow them freedom to innovate considering the resources and constraints of their respective situations, and to make them primarily responsible for the success or failure of the improvement programme in their respective divisions. To prepare them for the task, they were given one summer's training in the new elementary mathematics–its philosophy, emphases, instructional approaches and content.

All the school divisions now have teachers using the new curriculum guides but the extent of use varies from one school division to another, the conditioning factor being mainly the quality of leadership exhibited by the division, district and school officials in the implementation of the new curriculum. If any, a specific outcome that may be claimed to have been achieved by the project is the growth of a more receptive attitude on the part of the teachers and school administrators towards the new elementary mathematics curriculum. In other words, the wall of 'fear' of or indifference to mathematics that stood between the subject and the teachers has been, in a large sense, toppled down.

Several problems and constraints of the project were as follows:

1. Inadequate financing to produce the number of curriculum guides for the elementary school teachers in the country.
2. Adherence to old practices of organizing in-service training. These old practices are not conducive to the promotion of professional competence in elementary mathematics among the teachers.
3. Lack of innovative skill among school administrators so that trained teachers are not effectively utilized in the re-training of other teachers.

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SINGAPORE

Structure of the education system

Formal education in Singapore provides for six years of primary education, four years of secondary education and two years of pre-university education. Primary education begins at the age of 6 and leads to the Primary School Leaving Examination (PSLE). Secondary education leads to the General Certificate of Education (GCE) 'O' Level Examination at the end of four years and to the GCE 'A' Level Examination at the end of a further two years. Pupils may take courses with an academic (science or arts), commercial or technical bias. Tertiary education is available at the universities for GCE 'A' level holders and at the polytechnic and technical college for GCE 'O' level holders. Pupils may also branch out to vocational institutions to pursue industrial training courses at the trade and artisan levels. Teacher training is conducted at the Institute of Education for GCE 'A' level holders, and technical college, polytechnic and university graduates. The structure of the Singapore system of education is shown in the diagram.

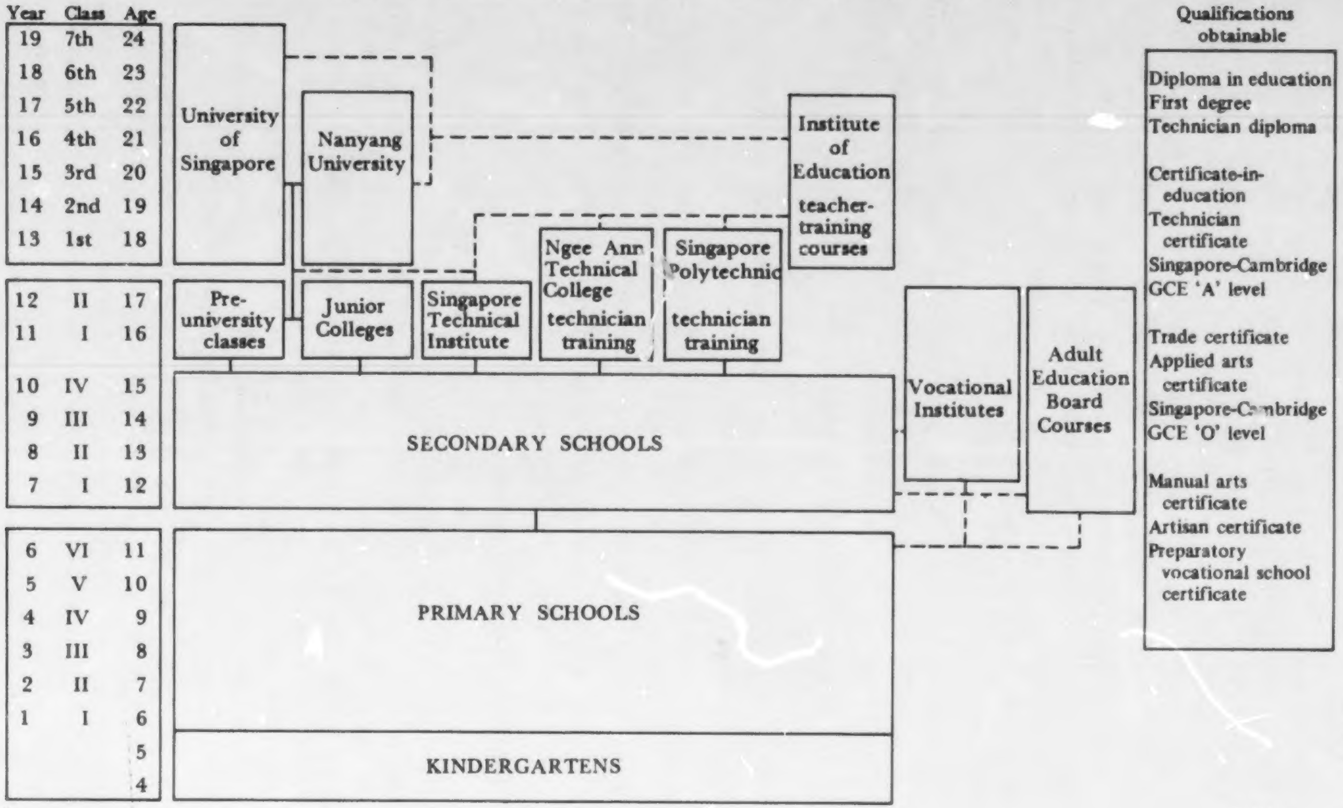
Primary science education

In 1970 Singapore embarked on a full-scale systematic curriculum revision programme in all subject areas under the Advisory Committee for Curriculum Development (ACCD) set up for this purpose. Various subject Standing Committees were formed to develop syllabuses and teaching materials. The Committee responsible for overhauling the science programme is the MESTAS Standing Committee, a joint committee of the Ministry of Education and the Science Teachers' Association of Singapore. A Primary Science Curriculum Development Team of this Standing Committee was instrumental in developing the science education programme.

The new Primary Science Programme aims at the active involvement of children in meaningful learning as well as the development of the understanding of scientific concepts and the acquisition of practical scientific skills. The Programme materials will eventually comprise teaching syllabuses, teachers' guides, pupils' worksheets, evaluation specifications/instruments and an experimental equipment list.

The programme is activity-oriented and, in the activities, pupils are guided to make observations, develop scientific concepts and acquire skills.

THE SINGAPORE EDUCATIONAL SYSTEM IN 1976


Year Class Age
19 7th 24
18 6th 23
17 5th 22
16 4th 21
15 3rd 20
14 2nd 19
13 1st 18
12 II 17
11 I 16
10 IV 15
9 III 14
8 II 13
7 I 12
6 VI 11
5 V 10
4 IV 9
3 III 8
2 II 7
1 I 6
5
4
University of Singapore
Nanyang University
Institute of Education teacher-training courses
Ngee Ann Technical College technician training
Singapore Polytechnic technician training
Pre-university classes
Junior Colleges
Singapore Technical Institute
SECONDARY SCHOOLS
Vocational Institutes
Adult Education Board Courses
PRIMARY SCHOOLS
KINDERGARTENS
Qualifications obtainable
Diploma in education
First degree
Technician diploma
Certificate-in-education
Technician certificate
Singapore-Cambridge GCE 'A' level
Trade certificate
Applied arts certificate
Singapore-Cambridge GCE 'O' level
Manual arts certificate
Artisan certificate
Preparatory vocational school certificate

Thus the trend is towards a child-centred curriculum with emphasis on pupil activity. Teacher-preparation programmes are organized alongside the production of instructional materials. Initially induction courses were mounted for primary school teachers to assist them in the use of the new programme. So far several courses have been conducted and more are being planned covering other aspects of teaching the new programme.

Every new curriculum programme has its problems and the new primary science education programme is no exception. Notwithstanding these difficulties, most primary science teachers have welcomed the new programme and view it as a challenge. Problems encountered include the following:

a) Teachers (whose earlier professional training in science teaching had a different emphasis) lacking in know-how to conduct lessons using the activity approach;

b) Teachers lacking in perception and related observation skills in science;

c) The activity method tending to generate noise thereby resulting in annoyance to neighbouring classes;

d) The difficulty in organizing pupils into groups and ensuring that every child is actively involved as effective supervision is difficult when class enrolment is large (usually 40 or more pupils per class);

e) Teachers facing difficulties in improvizing some of the suggested apparatus and materials.

Secondary science education

In the first two years of secondary education, all pupils are given a General Science course which is a loose combination of physics, chemistry and biology. At this level, pupils are introduced to science formally as they begin to learn to handle basic science apparatus and equipment in the laboratory. The teaching of this subject is still generally traditional, but this is expected to change when the revision of the primary science curriculum is followed through to the secondary level. Currently, a new programme known as the Lower Secondary Science (LSS) programme for the first two years of secondary education is being developed.

Basically, the LSS is a two-year integrated science programme. It attempts to exploit the innate curiosity of children about the environment through scientific exploration. It emphasizes (1) the understanding of basic scientific concepts in relation to the pupils' environment and their application to everyday situations, and (2) the acquisition of rudimentary skills and their application to the learning of science. It plans to include the study of the socio-scientific issues, such as environmental problems of overcrowding, pollution, rapid industrialization, urbanization and high-rise living. The programme will ultimately consist of six basic units and several optionals. The optionals are project-like in character and are intended to enrich the experiences of young people. The LSS is a significant departure from the traditional General Science course and is expected to replace it in future.

In the last two years of secondary education leading to the GCE 'O' level and a further two years leading to the GCE 'A' levels, pupils have a fairly wide choice of science subjects within the limitations imposed by staffing and facilities available in individual schools. Recently, physics and chemistry were withdrawn from the GCE 'O' level curriculum and replaced by physical science. At the GCE 'A' level, although physics and chemistry are retained as single subjects, pupils are encouraged to study physical science to allow them a wider choice of university courses.

As for the biological sciences, human and social biology have been introduced at the GCE 'O' level. Studies are also being carried out on the possibility of introducing a social biology course at the GCE 'A' level because of the possible breadth of this sort of subject delineation.

In Singapore, vocational/industrial training at artisan or trade level is provided by the Industrial Training Board (ITB). Artisan courses lasting from six months to one year are open to pupils who have completed primary education and trade courses to those who have completed a minimum of two years of secondary education. In the first year of the two-year trade courses for Secondary II and III pupils, academic subjects are taught, English, Mathematics and Science. Half of the first year's curriculum is devoted to these subjects, making a total of 630 hours divided equally for each subject. The primary aim for teaching these subjects is to enable pupils to understand and learn more effectively the theoretical aspects of the trades studied.

Problems encountered in the teaching of science

In the teaching of science to pupils in the vocational institutions the problems listed below have been identified.

Differences in academic levels of students. Although students from Secondary II and III are taken in for the two-year trade courses, their actual academic attainments vary very widely. Often teachers are required to teach in groups to cater for these differences. It is also found that the majority of the trade course students are those with low general academic ability. Motivating these students is a difficult task, as their interest in learning is often lacking.

Teachers. Trained academic teachers are currently teaching science. These teachers face the problem of having not only to teach principles and scientific concepts, but also to show the application of these principles and concepts in the respective trade disciplines pursued by the pupils. Under the present set-up the problem is compounded with these teachers having to teach pupils attending different courses.

Class size. The present class arrangement for science teaching is to combine two 'practical' classes. This could be made up of pupils from different language streams with varying levels in academic attainment. This large class enrolment has made effective control and group teaching extremely difficult, especially during practical science lessons.

Lack of instructional materials. There is a lack of suitable instructional materials, including textbooks; in mathematics and science and especially designed for vocational pupils.

In view of the problems outlined above there is need to pay more attention to the following areas:

- Revision of content to show the interrelationship between science and technology;
- Training of teachers specifically to teach science to vocational students;
- Development of special instructional materials for vocational students;
- Organization of remedial classes to cater for pupils of low general ability; and
- Collaboration between teachers teaching vocational subjects and those teaching science and mathematics.

Resources for the improvement of science education

Science teaching centre. A science teaching centre has been established in Singapore to provide a place for teachers to meet and discuss professional matters and design and construct science instructional aids. It is also used for conducting in-service science and applied science courses.

Educational television. Educational television plays a significant role in education in Singapore. Science and technical drawing programmes are televised for school pupils. The programmes are aimed at enriching the experiences of school children both at primary and secondary levels.

Equipment production. The Singapore Institute of Standards and Industrial Research (SISIR) is a quasi-governmental body which is responsible for maintaining the prescribed standards of locally made goods. Part of SISIR's work is developmental and in this respect it has embarked upon designing and producing prototypes of sophisticated equipment for use in secondary and vocational courses.

Out-of-school science education. Among pupils' school activities are organized visits to places of educational interest. Visits to places such as the Bird Park, the National Zoo, the Van Kleef Aquarium, the National Museum, and the various reservoirs, gardens, power stations and factories are invariably part of a school's calendar. The aims of such visits are to train children in making observations, to enhance their interest in science and technology education and to relate real-life situations to classroom learning.

Computer appreciation. The need to familiarize pupils with the fundamentals of the workings of the computer has been recognized and, in 1973, a computer training centre was set up with the assistance of the Government of Japan. The centre is equipped with a mini-computer and to date 90 teachers have undergone training on a part-time basis. These teachers have in turn conducted computer appreciation courses for their pre-university pupils. The courses are conducted outside normal school hours and are aimed at giving pupils an awareness of the *potentialities* as well as *limitations* of computers.

Applied science activities. Often the teaching of science at the second level is done along traditional lines and students learn largely by memorizing facts from textbooks. Many do master the science concepts but few are really able to apply the scientific principles to the solution of simple everyday problems. With the assistance of an expert from the United Kingdom, in-service courses on applied science are being conducted for interested teachers. These teachers on completing their training help their students in carrying out projects of an investigatory or 'discovery' nature. These pursuits should stimulate critical and creative thinking and help students to understand science better.

The Singapore Science Centre. The Singapore Science Centre was conceived with a view to stimulating a continuing interest among school children and the general public in the principles of science, their application in technology and their significance in everyday life. The nearly-completed Centre has facilities and a variety of educational aids to enhance the science (and technical) education programmes in schools.

Conclusion

Everywhere and at all levels industry depends on education. Science and technology, education and industry stimulate one another. It is imperative, therefore, that education for industry must rest on a sound basis of primary, secondary and technical education. In this connection, curriculum reform and the development of methodology must both take an important part in the improvement of the quality of science education in Singapore. Assistance from local tertiary institutions of learning and professional bodies, as well as regional educational centres, will also help in this regard. In the final analysis, however, it is the conviction on the part of teachers themselves of the need to increase their knowledge of contemporary approaches and improve on their teaching techniques which is vital to the successful implementation of any educational programme.

SCIENCE EDUCATION PROJECTS

Lower-Secondary Science (LSS)

Background and objectives. The project aims to reach all Secondary I and II students in Singapore schools. This is a development programme, and tryout of the project is being undertaken in ten secondary schools to be named Study Centres.

In 1970, Singapore embarked on a full-scale curriculum development exercise in all subject areas. Under the Advisory Committee for Curriculum Development (ACCD), various subject Standing Committees were formed to work on the revision of syllabuses. The Committee responsible for overhauling the science curriculum was the Ministry of Education and the Science Teachers Association of Singapore (MESTAS) Standing Committee. Along with the revision of the primary science curriculum the MESTAS Standing Committee decided that, for the second level, priority should be given to Secondary I and II (lower-secondary).

The aim of the project is to update content and methodology in science not only through the production of instructional materials but also through teacher-training programmes. The project seeks to provide a more imaginative structure for teachers to carry out their science teaching assignments more effectively.

Briefly, the LSS project attempts to exploit the innate curiosity of youth for the environment through scientific exploration. It emphasizes (1) the understanding of basic scientific concepts in relation to the local environment, and their application to everyday situations, and (2) the acquisition of skills and the application of such skills to the learning of science. It leads pupils into a discussion of basic science concepts and draws their attention to issues of a socio-scientific nature, such as social responsibility in science, environmental problems of overcrowding, pollution, high-rise living, drug abuse and rapid industrialization and urbanization.

Project design, development and implementation. The units for LSS teaching are based on broad themes. The programme consists of basic and optional units. The basic units comprise the following: Exploring science, Structure of matter, Energy, Water and solutions, Ecology, and Social biology.

The optionals are project-like in character and are intended to enrich the experiences of children. Tentatively, the following topics have been identified: Basic electricity, Corrosion problems, Some aspects of pollution, Cosmetic science, Elementary marine biology, and Making scientific toys. To date, several teaching units have been completed and work on other units is in progress as the total project is scheduled for completion in 1976. Plans are at hand for the tryout of materials in ten pilot schools in 1977.

Problems associated with the project. The LSS curriculum development team consists of about 40 members. The majority of the team members are teachers in service who have volunteered for this work. The LSS programme is significantly different from the traditional General Science programme currently in use in schools. Most if not all of the science teachers at this level will need guidance in the use of the project materials. In-service courses will have to be conducted for teachers to familiarize them with the instructional materials. It is estimated that at least 1,000 teachers should undergo the LSS course before the programme can completely replace the traditional General Science course in the schools.

Applied Science Courses

Background and objectives. The courses are designed for teachers teaching science in the secondary schools. The teachers trained will then introduce applied science investigations and project work activities to secondary school students as an extra-curricular activity and thereby help to stimulate interest during normal teaching periods.

A survey was conducted in 1973 to ascertain the extent of involvement of schools with applied-science investigations. The survey indicated that only in about one-third of the secondary schools were applied science activities carried out; most of these activities were undirected. In some cases, excellent projects failed to be completed mainly because of lack of expert advice. With the 'better' schools the pupils on their own initiated a number of high-quality projects ranging from electronics to bio-psychology. There seems to be no shortage of talent for project work in these schools. With the 'weaker' schools, however, much project work was of the construction type based on blueprints or circuits supplied by science magazines and textbooks.

Project development and implementation. By Applied Science Investigations is meant the application of scientific principles to the solution of everyday problems.

Two part-time courses were conducted in 1975, each lasting 60 hours, at the Science Teaching Centre at Anderson Secondary School. The first course was for teachers teaching science at the lower secondary stage.

These teachers were non-graduates and their theoretical background was reinforced with more detailed lectures. About two-thirds of the time was devoted to practical work. The second course was for teachers teaching science at the GCE 'O' and 'A' levels. These teachers were mainly graduates, and more emphasis was placed on investigations and projects. About three-quarters of the time was devoted to practical work.

Both courses were aimed at stimulating participants to think critically and imaginatively in seeking solutions to problems around them and to design and construct prototypes to solve these problems. Hopefully these pursuits would culminate in models or adaptations or 'inventions' of utilitarian value. Experiments which are merely extensions of basic scientific principles and which end up with only a theoretical conclusion or an accumulation of data are discouraged. Nor is the construction of models based on blueprints or circuits found in textbooks and periodicals in line with the present idea of project work.

Future plans. To date, 40 teachers have been trained. The many teachers already trained will introduce applied-science investigations and project work to their pupils in 1976. The training of teachers will be continued until at least one teacher in the lower-secondary classes and at least one teacher in the upper-secondary classes in each school have been trained in such activities. Not all pupils will do project work, but some interested pupils are expected to make project work an extra-curricular activity.

Computer Appreciation Courses

Background and objectives. The project aims to reach at least one teacher of science or mathematics in each secondary school and eventually all pre-university students. This is a development programme to introduce secondary school teachers to the basic knowledge of computer science. The teachers so trained will in turn expose their students to computer appreciation courses as an out-of-school activity.

In June 1973 the Ministry planned to introduce a basic non-examination course in computer appreciation to our schools. This would give pupils an awareness of the potential and limitations of computers as a tool and probably interest a few to make a deeper study of them at a later stage.

Project development and implementation. Teachers with a good mathematics background were selected to undergo a 60-hour Computer Appreciation Course consisting of 20 hours of lectures and 40 hours of computer practice. They were taught to work with a mini-computer using the high-level computer 'language' BASIC, which is used mainly in educational and scientific programming and allows interactive programming. Eighty teachers were selected to attend training courses on a part-time basis at the Computer Training Centre to be set up at Monk's Hill Secondary School, Winstedt Road. Five teachers have since received advanced training in Japan.

The Computer Training Centre was opened in 1975. Groups of 20 Pre-university students were selected, on the basis of their performance in science and mathematics, to join the Computer Appreciation Course. The Course consists of two parts: eight hours of lectures conducted by trained teachers in their own schools and 12 hours of computer practical work in the Computer Training Centre, and covers the following topics:

- Basic configurations of a computer, and their functions;
- Peripherals of the computer;
- Introduction to the various computer languages;
- Control and commands of the FACOM U-200 system;
- Introduction to the statements and 'syntax' of the BASIC 'language';
- Discussion on various examples of daily experience that can be solved by the computer, such as savings problems, drawings, mathematics problems and simple scientific simulations.

The entire course was conducted as an extra-curricular activity. By the end of 1975, 430 pre-university students from 27 secondary schools and junior colleges had been exposed to the programme. With additional equipment in 1976, double that number took the course.

To overcome the shortage of suitable texts for such courses, the Ministry of Education issues to each school a set of detailed guidelines for the teachers.

By the time students finish their first practical lesson they begin to realize the *limitations* of the computer as a machine while appreciating its power. They also realize that the capability of the computer depends to a great extent on the person controlling it.

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SRI LANKA

School structure and planning

The present school system comprises three segments: Primary school (grades I–V, Ages 6+ to 10+); Junior secondary school (grades VI–IX, Ages 11+ to 14+); and Senior secondary school (grades X–XI, Ages 15+ to 16+). All pupils follow a common curriculum up to grade IX, when a national examination will be held for the award of the National Certificate of General Education (N.C.G.E.). The secondary school curriculum consists of a common core (25 per cent) and five optional streams (75 per cent). All pupils follow the common core and select one of the optional streams. At the end of grade XI, there is a national examination for the award of the Higher National Certificate of Education (H.N.C.E). Admission to universities and other institutes of tertiary education will be made on the results of the above examination. Those who are selected for university education will have a further year of study (12th year or foundation year) to provide the foundation necessary for university education.

Educational planning is the responsibility of the Ministry of Education. The Planning Division of the Ministry of Education prepares the education plans (e.g. the Medium-Term Plan 1972–77) in accordance with the general policy of the Government and the overall developmental plans of the nation. The Curriculum Development and In-service Division based at the Curriculum Development Centre is responsible for designing the curriculum and preparing curriculum materials to meet the broad aims stated in the plans. The in-service teacher education programmes linked to these curriculum changes are also designed and organized by the Curriculum Development Centre.

The Schools Organization Division is responsible for printing and distributing the curriculum material and also for providing the human and material resources for implementing the new curricula in schools.

Science education at the first and second levels

Primary level (grades I–V). It is believed appropriate at the primary level to encourage an approach to science integrated within the whole curriculum. A primary science curriculum is being designed where activities and experiences leading to the formation of science concepts are developed within the environmental studies curriculum. The science component of this curriculum is expected to provide the child with a structured series of activities which will help him to order his experiences, thereby helping him in forming concepts.

Junior secondary stage (grades VI–IX). All pupils follow a common curriculum embracing science, social studies, humanities, pre-vocational studies, aesthetics, health and physical education. In this context, the science curriculum has been designed to serve the objectives of general education for *all,* with the emphasis on the application of these disciplines to life and the world of work. To achieve the above objectives, science is taught not as separate subjects in the form of chemistry, physics and biology but as an *integrated science* course.

In designing a four-year integrated science course for all pupils, effort has been made to relate it to the local environment and to make the material and experiences more meaningful from the point of view of its applicability and usefulness in everyday life.

Senior secondary stage (grades X–XI). At this stage all students follow a core curriculum and select one from five optional streams. The science stream is organized as below.

Grade X – The curriculum is common, and comprises:
1. Physical science (Physics/Chemistry)
2. Biology
3. Mathematics

Grade XI – Pupils have the option to specialize in certain subjects according to the following:
1. Physical science (Physics/Chemistry) and
2. Either (a) Mathematics, (b) Applied Biology, or (c) Agriculture.

Preliminary work has been started to provide a further option called Technical Science (applied physical science). The second-level science courses are designed with employment orientation in mind as far as possible, without unduly watering down the intellectual rigour of science courses suitable for this level and practicable with the resources that are available in the schools.

Technology education. Since 1972, with the introduction of prevocational studies into the junior secondary school curriculum, technological education has become a major compulsory component of general education of all pupils. It is not expected that students acquire the degree of proficiency required for practising the vocation after leaving school, but those who complete the course will have the confidence that the learning of vocational skills brings with it, (hopefully) develop healthy attitudes to wards manual work and appreciate the dignity of labour. They will also discover that the knowledge acquired in other disciplines such as science and mathematics can be applied to real-life situations and vocations.

Organization and institutional arrangements

At the national level, these are the functions of the Ministry of Education. The Curriculum Development Centre under the Ministry provides the designs and prepares the material for the entire school system, and the Schools Organization Division provides the human and material resources necessary throughout the country. These resources are allocated to the educational districts according to their needs; the organization of the programme within each district is done by the Regional Director of Education. 'Circuit Education Officers (Science)' assist the Regional Directors in the organization and institutional arrangements.

Schools are encouraged to make use of local resources such as research institutes, extension centres, and industrial and agricultural centres, in the public and private sectors for developing science (and technical) education programmes. Except at the primary level, where science has been integrated into the environmental studies curriculum, the Ministry has specified the organizational aspects such as the teaching time, teachers' qualification and laboratory facilities.

Supply of instructional materials

Curriculum materials for teachers such as syllabuses and teachers' guides are written and published by the Ministry and supplied free to schools. Pupils' textbooks are also written and published by the Ministry but are distributed for sale to pupils through booksellers. Only the textbooks published by the Ministry may be prescribed by heads of schools for regular use, but pupils are free to use additional background and enrichment materials published by private publishers.

Science equipment, tools, chemicals and other materials are supplied directly to schools by the Ministry. The Ministry maintains central science and handicrafts stores for this purpose. Schools are permitted to purchase certain consumable material from their own funds to supplement what they receive from the Ministry and to overcome temporary shortages.

Most of the science equipment, tools and chemicals are imported from abroad at the cost of a considerable amount of scarce foreign exchange. Attempts are being made to expand the quantum of equipment that can be manufactured locally at the Science Equipment Production Factory in the Ministry as well as by the public corporations and the private sector. A Science Equipment Design Unit has been set up at the Curriculum Development Centre to assist the production unit at the factory.

Training of teachers, research and evaluation

There are no specialist science teachers at the primary level. Teachers who have undergone a two-year course of training at a general teachers' college are employed in schools at this level. These teacher education courses include some general science.

There is provision to train science teachers for the junior secondary stage at specialist teachers' colleges which provide special courses in science education. There are three such special teachers' colleges.

Science teaching at the senior secondary stage is done mainly by university science graduates. The education faculty of the university provides them with post-graduate professional training leading to the Diploma in Education. The university also provides a two-year course leading to a science certificate at a level less than a first degree which is accepted as a qualification to teach science at the senior secondary level.

The Curriculum Development Centre provides in-service education to science teachers at all levels. These in-service programmes are specially geared to the new curricula.

Feedback information about the actual field situation obtained through seminars, questionnaires and school visits, and from teachers, in-service advisers, and field supervisors, provides some data for evaluating the programme. Pilot tests are also being conducted to determine the level of achievement and areas of difficulty of the pupils. Diagnostic tests are being planned in certain units to determine the difficulties of pupils. Remedial teaching material is being prepared to overcome problems revealed in the diagnostic tests.

The Examination Department conducts the national examinations at N.C.G.E. and H.N.C.E. level.

Main trends and objectives

Significant changes have been made in the aims of secondary education. A definite trend in the formulation of aims and objectives for this stage of education has been the increasing concern that students should participate in the solution of what may be called life problems. State investment in science (and technology) education at the secondary stage is no longer viewed only as a base on which engineers, architects, doctors and other professional scientific and technical experts are produced. Rather, it is deemed essential because the people need to participate in the solution of life problems; this demands the application of certain knowledge and skills which are best acquired through a study of science and technology. Emphasis has been laid not just on acquiring competencies which may be used later but on using them *right now.* The students' learning activities are expected to be of some direct social use to the community in which they live. In fact, the trend is to regard this type of learning activity as a very desirable way of learning. The take-off point is not a problem of mere academic concern. The curriculum worker does not look towards the subject matter books or browse through the library searching for 'projects' and 'problems'. Nor does he consult experts in the subject matter for suitable problems. His consultant is more likely to be the rural development officer, the medical officer, the forestry officer or the farmer. Committees which have been set up to advise the curriculum development teams have had as their members not only specialists in the subject matter but representatives from such areas as manufacturing, transport, irrigation, fishing or crop growing.

The junior secondary stage has seen the absorption of a wide variety of vocationally-biased subjects into the school curriculum. The present scheme enables a junior secondary school to propose a completely new syllabus if it is so inclined. The revision of the science and mathematics curricula, while maintaining the structure of these disciplines, will pay more attention to the use of science and mathematics in each vocation. At the senior-secondary level all students are expected to devote about ten per cent of their school time to activities designed primarily to serve the community. Science and mathematics students are expected to make a significant contribution to these activities which will demand some degree of technological competence. Some examples of the kind of activities expected range from the repair of agricultural machinery, to the production of handmade paper, to stage lighting. At the senior secondary stage, some special courses are also being designed. These have a strong technological bias, as the names themselves suggest: technical science, applied biology, for instance.

The Ministry has taken preliminary steps to co-ordinate the work of its technical education division with the senior secondary stage. It is very likely that the technical science course referred to in the previous section will be made available in the premises of the technical colleges. The staff of the technical colleges and the senior secondary schools are expected to collaborate in this effort.

At present, certain institutes are identified with certain types of education. This institutional isolation is very likely to break down, mainly because a developing country cannot afford the luxury of unutilized resources of a very scarce and critical type. The other trend is a blurring of the boundary between general and technical education. In the sphere of curriculum development, a trend which is already firmly established is the co-operation between both branches.

Reference has already been made to the use of community problems as learning resources, particularly for the new senior secondary schools. A trend which can now be considered to have been established at the junior secondary stage is the use of community experts as teachers or consultants. Here, by community experts is not meant the recognized professionals with post-graduate qualifications—their services have also been obtained. The reference here is to expertise at what is generally called the village or craft level. It is no longer uncommon that an instructor at an in-service session for teachers is the local expert who may have never attended a technical college or even a school for that matter. The Ministry is now revising some of its financial rules to permit an adequate fee being paid for such services.

At the senior secondary level too, this trend is expected to continue but the personnel are likely to be from some higher levels as well. In some of the pilot projects underway, rural development officers, forestry officers and others are instructing senior secondary students. The Minister of Education has made a request to enact legislation which would recognize such instructional work done by these State officers as being within their normal duties. In fact it is very likely that funds from other ministries may be made available for projects in which secondary school students are expected to participate.

In the area of teacher preparation, considerable emphasis is being placed on in-service education. The trend is towards a decentralized scheme, making use of selected teachers themselves as instructors. The courses are of short duration conducted at varying intervals throughout the year, in centres fairly easily accessible to the teachers. The Ministry has already commissioned the construction of ten regional centres for in-service education. In course of time each region is expected to have such a centre. At the moment, each region has a full-time staff for in-service education in selected subject areas such as science, mathematics, English, social studies and pre-vocational studies. The staff consists of teachers who have been relieved of their teaching duties and then trained by the Curriculum Development Centre for in-service education work. The trend, therefore, is the recognition of in-service education as a continuing service which has to be provided for the teachers. Pre-service education alone is recognized as being inadequate to keep the teaching staff up-to-date.

Another trend in the local scene is the increasing participation of the Sri Lanka University in the in-service education of teachers. One campus of the University has a separate department for technical teacher education. While this was set up mainly for the education of teachers of the technical colleges, the services of this department are being obtained for the education of secondary school teachers. Other campuses have offered a part-time course in mathematics for secondary school teachers. More courses of this type are expected.

The changing aims of secondary education have of necessity led to significant changes in evaluation. One of the aims of pre-vocational studies introduced into the junior secondary school curriculum is the acquisition of selected manual skills related to a vocation. An assessment of these has to be done at school level. There are other objectives whose assessment must be made a responsibility of the school. Under the scheme now in operation, a grade given by the school is recognized in awarding a final national grade to a student. Pilot projects now underway are testing the feasibility of using local committees to assess certain work due to be undertaken by the new senior secondary school students. All this activity indicates a movement away from a strong centralized examination system which, while it is now manned exclusively by local personnel, has been a legacy of the colonial past. An emerging trend is the establishment of regional examination bodies and increasing recognition of school-level assessment for certification purposes. Along with this there is likely to be a de-emphasis on foreign recognition of local certificates.

A SCIENCE EDUCATION PROJECT

Junior Secondary School Integrated Science Project

Objectives and project implementation. The target population of the project is students of grades VI to IX (junior-secondary school). The project was designed to produce integrated science teaching material to *all* pupils in the above grades and provide in-service education to teachers. This is part of the compulsory national curriculum in general education set forth by the Ministry of Education.

The project consists of the preparation of syllabuses, teachers' guides, textbooks, evaluation material and in-service education material. A curriculum committee consisting of curriculum specialists and practising teachers was set up for preparing the above material. Seminars and discussions were held with Ministry staff, research and industrial workers in scientific institutions, teacher educators and field officers. The human and material resources in schools were taken into consideration in drafting the curricular material.

The four-year syllabus was first drafted and adopted. Teachers' guides and pupils' texts were written simultaneously by the same committee. No field trials were done.

Pilot question papers were designed for pilot achievement tests. Such tests were carried out in a national sample of schools to determine the achievement levels of the pupils.

In-service education courses were designed and implemented by the curriculum committee with the assistance of field staff. All teachers have been exposed to some in-service education.

Evaluation. The project was implemented progressively beginning from grade VI in 1972 to grade IX in 1975 on a national scale. Evaluation is being done through pilot achievement tests, teacher questionnaires, pupil questionnaires, school visits by curriculum staff and field supervisors, and through teachers' seminars and in-service advisers. A full-scale revision based on the data obtained by all of these evaluation sources is being done by a group of teachers who have taught the new curriculum.

Problems. The main problems are the difficulties encountered in getting the required quota of professional qualified teachers and providing all the schools with the facilities, equipment and material for experimental work.

Future plans. The following observations may be made:

a) A major revision of the existing curricular material will soon be completed;

b) The in-service education programme will be improved and expanded;

c) Background reading material, student workbooks, and students' out-of-school projects will be developed.

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THAILAND

Structure of the education system

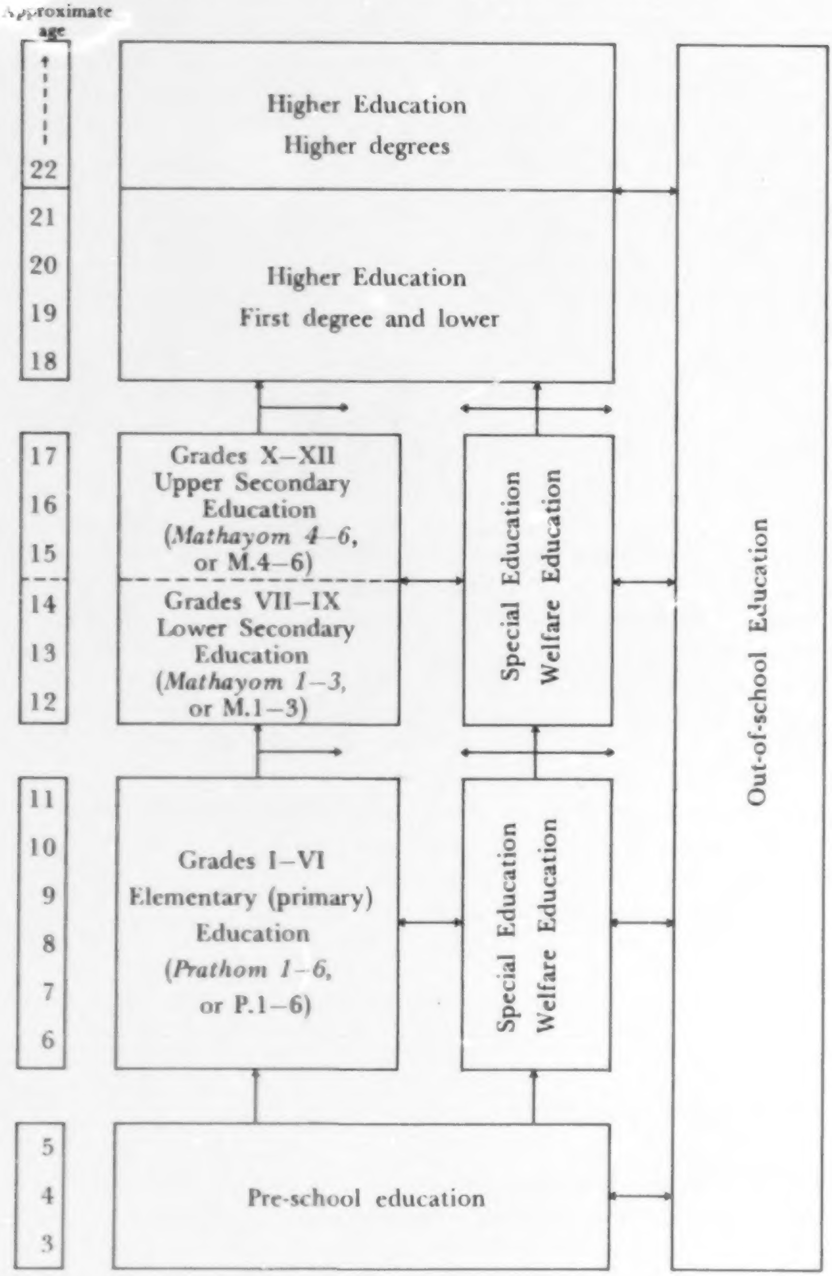
The education system in Thailand provides for seven years of primary education, three years of lower secondary and two years of upper secondary education. Primary education aims to promote the development of all children and is compulsory up to four years. Secondary education follows elementary (primary) education and aims to explore and promote individual needs and abilities. It is organized into two streams, general and vocational. At the end of secondary school, students are expected to have sufficient knowledge and skills to apply for admittance to institutions of higher learning. Schools in the vocational stream are of several types, with courses of different lengths depending on the nature of the trade or profession. Vocational schools may admit students who have finished elementary education or who have finished the lower secondary grades. Higher education deals with study and research in the higher academic and technical fields. Higher education may be carried out by the government or by the private sector under government regulation.

A new movement of educational reform indicates that the present 7–3–2 system will be altered to 6–3–3. The cabinet has approved this reform and scheduled the change for 1978/1979. This means that the duration of primary education will be reduced to six years and secondary education increased to six years, three for lower and three for upper secondary education. This new national scheme of education is shown in Figure 1. The Thai terms for primary education (*Prathom*) and secondary education (*Mathayom*) are also given.

Science education at the first and second levels

The teaching of science in primary schools is more towards nature study. The present curriculum has been used in schools since 1960. While the aims as stated in the syllabus are as good and universal as one would expect today, teaching of science at this level varies from school to school depending on the qualification of the teachers and the availability of teaching resources. In some of the top schools with adequate teaching materials, the teaching of science is geared towards student activity. It is generally true, however, that in most schools the teaching of science is of the didactic type.

Figure 1. The Educational System of Thailand


Approximate age
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
Higher Education
Higher degrees
Higher Education
First degree and lower
Grades X–XII
Upper Secondary
Education
(Mathayom 4–6,
or M.4–6)
Grades VII–IX
Lower Secondary
Education
(Mathayom 1–3,
or M.1–3)
Grades I–VI
Elementary (primary)
Education
(Prathom 1–6,
or P.1–6)
Special Education
Welfare Education
Special Education
Welfare Education
Pre-school education
Out-of-school Education

In 1975, the National Curriculum Development Centre (NCDC) initiated a curriculum reform programme in all subject areas. The Centre is trying to eliminate the subject boundary as much as possible and to emphasize the integration within and between subject areas. The four subject areas are: Skills (Thai and mathematics), Life Experiences (science, health and social studies), Character Education (moral education, civic duties, music, arts and physical education) and Work Education (household work, agriculture, arts and crafts, service and trade, and laws and legislation).

Science is now integrated with health and social studies. Objectives and content outlines have been drafted. Teacher's guides, students' worksheets and any other teaching materials were prepared and tried out in a certain number of schools in all geographic locations in 1976. Revision of all teaching materials and the training of teachers is being carried out in 1977. Implementation for grade I (*Mathayom 1* or M.1) is to be in 1978. Grades II to IV are to be implemented by 1984.

The NCDC is now facing the tremendous task of trying to produce teaching materials, including experimental kits. The change is rather drastic in the sense that science is not taught as a subject but to be integrated with the social and health studies. 'Integration' has its own merits as well as its disadvantages. In some areas, like history, it is almost impossible to try any integration with science. Moreover, primary school teachers are not familiar with this approach; therefore a good in-service training programme is vital to the success of the project. The number of first grade (grade I) teachers alone is on the order of 50,000, so one can see that the NCDC will have to find some means giving an in-service training economically and effectively to its primary and secondary school teachers.

In 1972 the Thai government established a large curriculum project under joint sponsorship with Unesco known as the Institute for Promotion of Teaching Science and Technology (IPST). The purpose of the project is to develop, test and implement new courses in biology, chemistry, physics, general science, physical science and mathematics. Curriculum development in the IPST is carried out by six design teams working together with five servicing teams as shown in Figure 2.

The members of each team consist of a representative cross-section of teachers, supervisors, teacher training college instructors and university lecturers.

Present efforts of the design teams include preparing (1) mathematics and general science for lower secondary schools (2) specialized biology, chemistry, physics and mathematics curricula for the science stream of upper secondary schools and (3) physical science and mathematics curricula for the Arts stream of upper secondary schools. This is illustrated in Figure 3.

Figure 2. Organizational chart of IPST

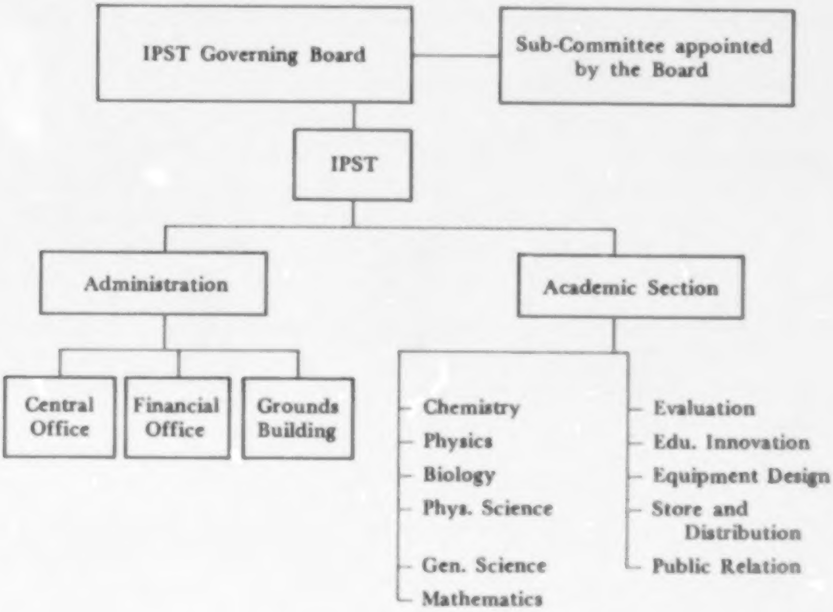
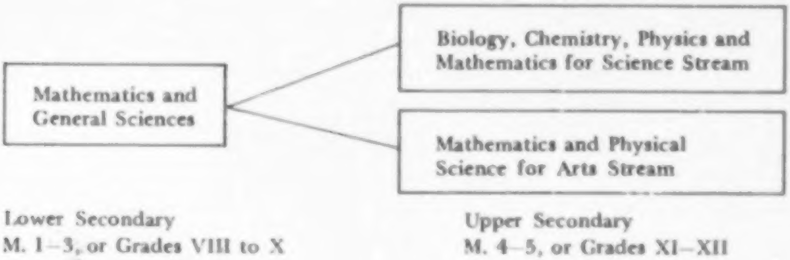

IPST Governing Board
Sub-Committee appointed by the Board
IPST
Administration
Academic Section
Central Office
Financial Office
Grounds Building
Chemistry
Physics
Biology
Phys. Science
Gen. Science
Mathematics
Evaluation
Edu. Innovation
Equipment Design
Store and Distribution
Public Relation

Figure 3. IPST curriculum being developed


Mathematics and General Sciences
Biology, Chemistry, Physics and Mathematics for Science Stream
Mathematics and Physical Science for Arts Stream
Lower Secondary
M. 1–3, or Grades VIII to X
Upper Secondary
M. 4–5, or Grades XI–XII

The initial decisions concerning the overall organization and philosophies of the new curricula were made after intensive studies of materials that have already been produced in other countries. Some of the major decisions of each team are shown below.

General science uses a unit approach with an effort to draw from all the sciences and integrate science process skills with the major concepts of science. Low-cost science equipment is produced locally and experiments are designed that can literally be performed on school desks.

Biology follows an activities-centred approach: it adopts material from foreign texts on universal topics but uses data collected in Thailand for local topics, focusing attention on developing instruction that will get the students to examine the biology of their immediate environment.

Chemistry integrates text and laboratory manuals in an effort to encourage teachers to teach chemistry as a learner-centred enquiry involving both theory and practice. It develops experiments and an inexpensive kit that contains most of the equipment needed to perform the experiments. It also introduces a study of Thai chemical industries and chemical problems that are relevant to the Thai society.

Physics presents physics as a single unified course containing mechanics, heat, light and sound, electricity and magnetism and laboratory experiments. It develops inexpensive equipment that can be manufactured locally.

Instructional materials

Policy and directions are given by the Curriculum Improvement Committee of the Ministry of Education. The development of curricula, textbooks, teachers' guides and other teaching materials is the responsibility of the Institute for the Promotion of Teaching Science and Technology. The IPST also takes responsibility in the training of teachers as well as the evaluation of the Project.

The publication and nation-wide distribution of teaching materials and the production of equipment is the responsibility of the Textbook Division of the Educational Techniques Department, Ministry of Education. Textbooks are normally purchased by the students.

Science equipment has been developed by design teams of IPST and prototypes constructed by IPST workshops. After the trial in schools, the equipment is modified. The Ministry of Education then authorises the Teachers' Association Factory to produce science equipment for schools throughout the country.

Slides, filmstrips and other audio-visual aids have also been produced, and the Ministry of Education is looking into mass production for schools from the master copies developed at IPST.

Training of teachers and other educational personnel

The Teacher Training Colleges and Universities are the institutions responsible for the pre-service programme. There are the following levels of training: 'Certificate in Education', which takes two years beyond grade X, and the 'Higher Certificate in Education', which takes two more years after the first Certificate in Education. Degrees in education, such as B.Ed. and M.Ed., are also offered.

Teachers with the Certificate in Education normally teach in primary schools whereas those with Higher Certificate or degree in education teach in secondary schools.

The IPST in-service training programme was launched one year prior to the implementation of each science subject. In 1975 about 1,700 teachers went through a three-week intensive course for lower-secondary general science and about 1,600 teachers of physics, chemistry and biology took similar courses for the teaching of those subjects in the upper secondary stage. Similar courses have since been organized for higher grades. In-service training for physical science and mathematics teachers is also in progress. The establishment of 13 regional centres recently was a great help towards the in-service training of lower secondary teachers in science and mathematics.

The in-service training of elementary (primary) school teachers is quite a problem due to the great number of teachers. The Ministry of Education decided that, for economical reasons, the in-service training of primary school teachers should be carried out once for all subjects. Thus the training of primary teachers in mathematics and life experiences is underway in 1977, one year prior to the implementation in 1978.

Research and evaluation in science education

A curriculum development project as large as IPST needs access to a great deal of data about the educational system in which it works. Some of the information normally considered fundamental to curriculum development and implementation has not been collated. The evaluation team of IPST has undertaken a series of research activities. The instruments and researches conducted to study changes in the IPST trial students are the following.

1. An analysis of test items in all trial subjects to examine their qualities so that the design teams can carry on the improvement and select them for further use;
2. A summary of mid-year and year-end examinations conducted at the IPST trial schools;

3. A survey on lower secondary (group 1) students' opinions on chemistry, physics, and biology;
4. Reports on the students' opinions, and general problems arising from the learning/teaching of IPST curricula;
5. A report on the survey of teachers' attitudes towards chemistry, physics, and biology;
6. Reports on the survey of students' attitudes in chemistry, physics, biology, general science and mathematics at the IPST trial schools as well as some other schools in 1974;
7. A comparative study of scientific attitudes, knowledge, understanding of science processes and interests of first-group students both in and outside the IPST trial programme;
8. Comparative studies of lower secondary students' achievements in science learning, and interests and attitudes towards science, both in and outside the IPST trial programme. (Two groups tested);
9. Comparative study of higher secondary students' fundamental achievement in mathematics learning, interests, and attitudes towards mathematics, in and outside the IPST trial programme;
10. Readiness in the learning of primary grade I (P.1) mathematics;
11. A Science Process Skills test;
12. Comparison of achievements in science learning of IPST students and students following the traditional curriculum by means of the International Education Association test.

University students have also undertaken research projects under the guidance of IPST staff. The titles of research included: "The study of backgrounds in chemistry, and attitudes of chemistry teachers"; and "Programmed instruction for the teaching of chemistry".

A major step in the IPST's developmental research began in 1976 when the Unesco IPST doctoral fellows returned from their overseas universities to begin research at the IPST for their doctoral theses. The value of the curriculum development research it generates is becoming evident.

Current trends in science education

The curriculum projects in science and mathematics developed by IPST since 1971 are now in the process of being implemented in schools throughout the country. The implementation of general science for the lower secondary stage, and chemistry, physics, biology and physical science for the higher secondary stage began in 1976. Mathematics for higher secondary is being implemented in 1977 and for grades VII and I (first grade) in 1978. Mathematics for the subsequent grades will be implemented sequentially and will be complete by 1984.

The follow-up plan is now being prepared to evaluate the entire project in order to collect data and help teachers in the field in the teaching of the new courses. The curriculum will be continually evaluated and revised. In the near future, curriculum development for the vocational stream and for the first-year science courses at university level are being planned to improve the teaching of science in these areas. Co-operative effort among specialists therein is anticipated to set pace for such developments.

New courses in the area of applied science are among other interests for future development.

The training of teachers in science courses will be a major task of the IPST for a few more years until all have received training.

Large-scale production of the IPST-designed-and-tested science equipment has been made by *Kurusapha,* the commercial enterprise of the Teachers' Association. There are some five hundred different items of equipment and most consist of many smaller parts. UNDP is assisting with a small-scale UNIDO project to provide some training for the *Kurusapha* engineers and experts in industrial design and production engineering. Also, the IPST has created an industrial design division to check the equipment tested in schools for suitability for large-scale production. A quality control process is being developed between IPST and *Kurusapha.*

Problems in the development of science (and technology) education

The development of a new course under the title Life Experiences which aims to integrate science, social studies and health for primary grades is carried out by the staff of NCDC. Due to the shortage of qualified curriculum developers, the NCDC had to set up an *ad-hoc* committee to do the work. Usually the members of such committees are not released from their normal duty and thus suffer a great deal from the lack of time to devote to such an important task.

This new approach of teaching integrated subjects needs careful planning including the preparation of good teachers' guides and good in-service training. With such a large number of teachers at this level, the NCDC is facing an immense task of in-service training in the next few years. Moreover, most teachers in primary schools are underqualified and cannot be expected to carry out new content and procedures to attain course objectives without assistance from outside. Good supervision both within and outside the school system has to be strengthened to assist teachers in the teaching of new courses.

The secondary school science courses developed by IPST are activity-centred and require skills in using equipment and carrying out new experiments. Moreover, the teaching in the new courses is enquiry-oriented which is unfamiliar to most teachers. Since teachers usually employ the lecture style of teaching, many of them seem to resist changing to this modern technique of teaching science.

The IPST realizes the importance of in-service training, hence a large-scale training programme was carried out to give a three-week intensive course for each subject. The limiting factor seems to be the financial constraints which IPST is facing. Especially in the lower secondary schools, where there are more teachers, more budget is needed but it has been heavily cut. It is hoped that financial constraints can soon be alleviated.

Another problem concerning the implementation of the new science courses is the cost of new equipment although the IPST has tried to produce low-cost equipment. The Ministry of Education has made a survey of school equipment stocks to give assistance to schools if additional budget is required.

Test construction skill is one objective among others that the IPST hopes to develop for teachers during their workshop attendance. From 1977 onward, the Ministry of Education will eliminate the national examination and give responsibility to the schools to evaluate their students. Again, most teachers require extra training for test construction.

THE NATIONAL SCIENCE EDUCATION PROJECT

The Institute for the Promotion of Teaching Science and Technology (IPST)

Background and objectives. The Institute was established in 1972 by the Thai Government with assistance from Unesco/UNDP. The following objectives are set down in the Act establishing the Institute:

1. To initiate, execute and promote the study and research of curricula, teaching techniques and evaluation in sciences, mathematics and technology at all educational levels;
2. To promote and execute training programmes for teachers, instructors, lecturers, students and university students on the teaching of sciences, mathematics and technology;
3. To promote and execute research, development and production of science equipment and materials for teaching the sciences, mathematics and technology; and
4. To promote and execute the preparation of texts, exercises, references, supplementary materials and teachers' guides on the sciences, mathematics and technology.

In keeping with the above, the immediate objectives of the IPST are:

- To modernize the content and teaching approach of science in grades VIII to XII, and mathematics in grades I to XII, throughout Thailand;
- To augment the pre-service training and introduce in-service retraining of science and mathematics teachers and supervisors, introducing specially prepared instructional materials and using modern teacher training techniques;
- To achieve the widespread implementation of modern science and mathematics teaching in schools by providing teacher training and modern curriculum materials including books, manuals, teachers' guides and science and mathematics equipment.

Project implementation and evaluation. Representatives of each subject design team were given the opportunity to witness first-hand curriculum development processes through fellowships provided by Unesco. Workshops were organized for the purpose of exchanging views leading to the setting of objectives and content outlines. As a result, many bright young people were identified to help develop curriculum materials.

In each curriculum, four areas are developed concurrently, the writing of the students' text and teachers' guide, the evaluation, the teacher training and the development of science equipment. Writing of the drafts and trial of the text and teachers' guides and the revision and completion of the final manuscripts for printing set the pace and determine the schedules that the other areas must meet.

The evaluation team first prepares and pre-tests attitude, understanding and science process skills by using questionnaires and tests. These are administered to a control group and the trial group before and after the trials. Then when the trials begin in the schools, formative and achievement tests are prepared. At the end of the trials, the bank of test items—now pre-tested in the trial schools—are used to develop diagnostic tests to assist teachers in the early years of implementation.

Teacher training begins within the first year of the curriculum development. The teachers are brought to the Institute to try out experiments to assess their suitability, to discuss guidelines and chapter drafts and to test the first designs of science equipment. Some of these teachers become the trial teachers, who test the trial books, equipment and achievement tests. Some of the in-service instructors are selected from the trial teachers.

The design of science equipment begins also at the time of the first draft of the students' text. The first prototypes are tested by teachers, and redesigned and checked before being produced in amounts of up to 300 for the trial schools. After the first trials, equipment is redesigned where necessary and reproduced for the second trials. After completion of the second school trial, the equipment is given to the industrial design section and then to large-scale production.

Concurrent development of achievement tests ensures that the examinations are set on the new curricula to assess the achievement of objectives. The teacher training involves a considerable number of teachers in the development process and as a result they become identified with the new curriculum. Concurrent development of science equipment provides classroom testing of the equipment before manufacture.

Specific outcomes. Physics, Chemistry and Biology have been tested twice in 1973 and 1974 for Mathayom 4 and in 1974 and 1975 for Mathayom 5 in ten and 20 schools respectively. Textbooks, teachers' guides and equipment have been modified and are being produced on a large scale for implementation in 1976 for Mathayom 4 and in 1977 for Mathayom 5.

Physical Science has been tested in 'mini-trial' classes and is being implemented. Full implementation will be in effect in 1978.

General Science for lower secondary schools has been tried in 12 schools in 1974 for M.1, 1975 for M.2 and 1976 for M.3. Implementation began in 1976 for M.1 and the rest follows sequentially.

Similar trial programmes in mathematics were carried out for *all* grades. The implementation plan is as follows:

	1977	1978	1979	1980	1981	1982	1983
Elementary (Primary)		P.1	P.2	P.3	P.4	P.5	P.6
Lower Secondary		M.1	M.2	M.3			
Upper Secondary	M.4	M.5					

Teacher training programme. In 1975, about 80 per cent of teachers teaching M.1 General Science and teachers teaching M.4 Physics, Chemistry and Biology attended a three-week intensive in-service training. Similar programmes were then carried out for M.2 and M.5 science teachers.

Problems and successes. Over the period that the IPST has been working on curricula, a number of major changes in the national education scheme have been formulated and some have already been implemented. Two major changes are:

1. The introduction of a semester system and a credit system with a core of subjects plus electives;
2. The introduction of an internal school assessment system to replace the external centralized examinations in M.5.

A further concern involves the change from a 7–3–2 school system to a 6–3–3 system. The new curricula can be adapted to the proposed 6–3–3 structure of the primary and secondary schools. The senior sciences could retain the basic structure but could be spread over three years instead of two. The general science curricula could be used after six years' primary, and adjustment is now being made to M.1 mathematics so that it can be taken after Prathom 6.

In 1975, a joint UNDP/Unesco review mission visited Thailand and studied all activities of IPST objectively and made conclusions in approximately these words: ". . . the mission can confidently ascertain that to the present the project [is achieving] the following immediate objectives:

a) Creating a valid mechanism in support of activities leading towards a continuous science and mathematics curriculum development;

b) The design of science and mathematics curricula, equipment and teacher training materials for general science and mathematics courses (M.1–3) and biology, chemistry and physics courses (M.4–5);

c) Providing training for project personnel and teachers in-service. (However, major activities for the pre-service training of teachers have yet to be attempted);

d) Planning for the dissemination of the materials developed by the Institute;

e) Establishing an evaluation programme to permit internal revision and initiate external assessment;

f) Implementing a programme of research in science and mathematics for the preparation of teachers.

The Ministry of Education has proposed that the National Curriculum Development Centre (NCDC) become a sub-departmental organization within the Department of Educational Techniques. The NCDC will incorporate the Curriculum Division, the Textbook Division, and the Research Division of the Department as well as the IPST. The UNDP/Unesco mid-term review mission recommended that the Government accomplish the merger of IPST and NCDC in a manner which gives the resulting unit the operating conditions needed for effective educational research and development, which conditions are very much like those presently enjoyed by the IPST.

Bulletin of the Unesco Regional Office
for Education in Asia
Number 18, June 1977

UNION OF SOVIET SOCIALIST REPUBLICS

Note: *this article, like the preceding ones adapted from a report presented to a regional science meeting, is unique here in that it deals mainly with science education content, not its organization.*

In the cultural field, the Soviet Union has, within a historically brief space of time, traversed the road from putting an end to illiteracy on a nation-wide scale to introducing universal secondary education which is compulsory for all youth.

The goals of education are predetermined by the demands of society: "Education must provide a sound knowledge of the foundations of science, instil the principles of the communist outlook and provide work-oriented and polytechnical training which matches the growing level of development of science and technology and bears in mind the requirements of society, the abilities and wishes of the pupils, and ensure the moral, aesthetic and physical education of a healthy new generation." [1]

Considering the great changes in society life and the growing demand for highly trained manpower, the Soviet Union in 1966 took the decision to establish universal secondary education. At the same time, the level of general educational training has become higher. These facts dictated the following tasks for the Soviet school system: (a) to bring the subject matter and methods into line with the modern level of science and culture; (b) to enhance education's links with life, by promoting practical and polytechnical training, taking into account the requirements of society, and the aptitudes and inclinations of the students. These tasks may be solved due to certain democratic principles of the Soviet educational system, to the experience of many millions of teachers and to certain achievements in the field of science teaching.

The Soviet educational system comprises a comprehensive open-ended system covering all social groups. After receiving an eight-year education students may, according to their wish, move on into the secondary school, enter secondary technical or special professional educational institutions, or continue education at evening school while working in the daytime. All of these various forms of secondary education provide necessary training and give the right to enter higher educational institutions. Education is free at every level, from elementary school to higher education.

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1. *Programme of the Communist Party of the Soviet Union*, Moscow, Politizdat, 1971, p. 123.

There is no competition between higher educational institutions in the country; the government is equally interested in the functioning of secondary schools, colleges and professional training institutions. The aim is to prove to youth the necessity of at least secondary education.

Recent changes in Soviet schooling

Shortening the primary period of education from four to three years is the most important change. It was based on the latest scientific data on how younger children learn as well as on the great experience of Soviet schools and schools abroad. The data of experimental psychological and didactic research conducted in the past ten years has made possible a new system of elementary education throughout the whole country. The system has proved to be better than the previous one.

At the present time there exist generally-accepted curricula for all grades and all subjects. The new programmes envisage studies at a higher level of generalization and improvement of the logical treatment and theoretical analysis of the studied material, using both deductive and inductive methods of explanation. Attention is paid to developing independent thinking. The amount of informational and reference material requiring memorization is shortened. Excepting data necessary for everyday usage, learning such things as formulae, rules, figures, has been largely substituted for by training in the ability to use various kinds of reference books. Material for drilling exercises has been changed; it is no longer confined to mechanical training of practical skills, but requires a maximum thinking effort from the students, as it calls for the application of knowledge of theory under new conditions of practical and scientific activity.

Correlation of theoretical and descriptive material at different stages of school training has also been changed. A portion of the theoretical material has been transferred from senior to junior classes.

With regard to programme and methods, systematic courses in different subjects present a single whole and are covered in grades IV to VIII. According to the new curricula, 500 more lessons for studying the basic sciences are added to the programme. The transition of grade IV to the method of subject teaching provides more time for studying the native language (from 16 to 21 hours per week) and mathematics (from 35 to 40 hours per week) in all grades, despite a certain general curtailment of hours through the whole course of secondary school.

Secondary school has preserved the historically formed experience of combining humanities and natural sciences in general education. Humanities take up 40 per cent of the school time. One of the most important tasks of the school is the training of cultured, educated people with a good command of the Russian language and of the native languages of national schools.

The course of history is based on the ideological ideas of the leading role of the people in creating material and spiritual culture, in the struggle for the independence of the Fatherland. Scientific ways of changing the world are explained to the students, and they are taught to understand the role of every human being in the historical process. The scientific and aesthetic levels of studying fiction is achieved now by more detailed analysis of the creative personality of each writer, his ideologically-artistic individuality, and social and political as well as moral and aesthetical problems touched upon in various works.

New content in science and mathematics education

As to the natural sciences, the new curricula have provided more time for these subjects, which now take up 36.6 per cent of the whole school time. According to the modern level of scientific knowledge, each subject stresses the most important ideas reflecting the main tendencies of modern science in a form easy to grasp in the respective grades.

Mathematics has broken the artificial distinction between arithmetic and algebra; the material is now approached functionally. More attention is paid to teaching concepts and methods especially important in technical and natural sciences (for instance, methods of co-ordinates, vectors, derivatives and integrals).

Sound knowledge and skills are taught through the great number of relatively simple sums and exercises. Difficult and complicated sums and exercises which may be interesting only to a small portion of students have been given up. The learning of formulae has often been replaced by forming a skill of using reference books.

Using elements of differential and integral calculus while explaining traditional school problems (such as making graphs, counting volumes, studying functions and vector methods in geometry) gives certain economy in time. Some traditional problems have been excluded from the curriculum, among them the theorems of medians, bisectors and the heights of triangles, and the Heron formula. The theme of 'complex numbers' has been totally excluded from the algebra course (on the other hand, this has been included in much more detailed fashion in the course of Supplementary Problems in Mathematics which is to be taught in senior forms).

While composing the course in physics, the authors tried to avoid mere enumeration of single facts without any principal importance. At the same time, they realized the necessity of studying physics as an experimental science. This means the reproduction of the most significant and general facts and observations which help to formulate the general laws of physics. Besides, the most important and interesting fields of the application of physics must be given too.

It is very important to avoid dogmatic statements and arbitrary explanations of physical concepts and values: each concept should be actively used during the whole course. This principle may explain, for instance, why the programme does not include such a problem as the second law of thermodynamics, with its statistic interpretation.

A considerable portion of time is provided by the curriculum for experimental work by students, both in the laboratory and in practical work. This part of the programme is very important in the eyes of its authors. Laboratory tasks, experiments and excursions may vary, depending on the real conditions of work at different schools, but they must be equal in quality. The course in physics includes physical sums without which it cannot be mastered. The illustration of physics, including its technical application, is also of great importance.

The main improvements in the course of chemistry consist of further perfection of the theoretical level of the course and of further development of the principle of connecting studies with life—and practice.

To provide deeper theoretical knowledge, the course of non-organic chemistry envisages more complete study of the periodic chart of chemical elements: the students learn regularities of small periods and main subgroups of elements as well as large periods and lateral groups.

The structure of atoms is studied not only in elements of the first three periods, but in all following periods as well. Naturally, the task is not to memorize the ways of electron distribution in various atoms, but to understand the regularity in structure and the influence of structure on the properties of elements.

The scientific level of the course of non-organic chemistry is raised by way of adding to the classical theory of the chemical structure of matter by A.M. Butlerov, of the ideas of molecular structure in space and of the electron nature of chemical links. The scientific level of chemical studies is also achieved through an earlier beginning of theoretical studies, which also allow for the study of the major part of the material on the level of these theories.

In non-organic chemistry, the study of D.I. Mendeleev's period law and of the problems of chemical connection has been transferred from grade IX to grade VIII, and is taken up immediately after the students have learned the main classes of non-organic compositions.

The new curriculum in geography differs from the present programme by giving more weight to the general theoretical problems of modern geography. New concepts of physical geography are included at the expense of eliminating concentrism and a number of other topics and of strengthening the ties between different topics.

Biological education has undergone substantial changes. During recent years, the science of biology has achieved great success in studying life at the cell and molecule level. Major discoveries have been made in deciphering the structure of nucleinic acids and their participation in the synthesis of albumen, in finding out the genetic hereditary code. These achievements gave reason for reconsidering the whole school course of biology. The new contents of the school biology course have been formulated in compliance with the modern state of the biological science: there has been introduced the molecular grounds for genetics and selection. More ecological and physiological information, as well as information about achievements in molecular biology in discovering cell structure and functions are taught. Darwin's ideas have been restored: the principle of evolution is made the basis of the whole course.

The new programmes differ from the previous ones not only by including new problems at the expense of elimination of other items, but also by the direction of scientific content in them. Changes in the biology course have been especially remarkable in the senior forms. The scientific level of the courses of botany, zoology, physiology, and the hygiene of man has been considerably raised.

Selection of material for all branches of the school biology course has been conducted with consideration of the necessity of gradual forming of the main biological concepts. The programme provides not only for learning specific problems in each discipline, but also for establishing in the material studied of general biological regularities which are most fully described in the final course of general biology.

The courses of botany, zoology and human physiology give facts and certain theoretical generalizations which introduce students to the historical development of the organic world on the basis of Darwin's ideas, to the origin of humanity, to the cell doctrine, metabolism, reproduction of organisms, regularities in transmission of hereditary qualities, relations of organisms and environment. The course of general biology reveals the essence of the main laws of life, and of individual and historical development of organisms. It explains the molecular basis of cell structure and functions. The material for each section of the biology course is taken with consideration of the age of the students and the level of their knowledge. Therefore, for instance, the material on vegetation phylogenesis is given in grade VI in a more elementary form than is done in grade VII with regard to the phylogenesis of animals, and the concepts of the structure and function of cell organoids grow increasingly complicated from grades V to X. The whole course in biology provides for accumulating concrete facts and forming scientific concepts which are most completely described in the course of general biology.

The polytechnical principle in studying the basic sciences is achieved through making the students' acquaintance with the scientific basis for major fields of production. Thus, the course in physics deals with the most widespread mechanisms, heat, engines, ways and means of transferring and using electric power, communications, and electrical and radio equipment.

The chemistry course envisages making students acquainted with the most important fields and scientific principles of chemical production and the direction of chemicalization of the people's industry. The students learn the methods of production in such fields of chemical industry as sulphuric acid, ammonia, mineral fertilizers. While learning the processes of production of metals, construction materials and chemicalization of agriculture, the students would understand the importance of chemistry for the development of various branches of industry. The course in organic chemistry introduces the students to the production of organic products—chemistry of oil, natural gases, and so on.

Closely related to the scientific grounds for modern production and technology is labour teaching, a special school subject. In the first stage, from grades I to VIII, its task is to develop technical, agricultural and other daily skills necessary for work, as well as certain technological and technical knowledge. Classes are conducted at school shops, laboratories and school experimental lots. Labour teaching in grades IX and X presents a serious study of technology on a wide scientific and polytechnical basis in certain fields of work and provides initial vocational training. With this aim in view, special and scientific technical practical work is organized. School workshops, laboratories or neighbouring enterprises may offer students such types of practical work as technical drawing, study of automobiles and tractors, electrical engineering, radio engineering, chemical technology, plant growing or cattle breeding.

Modern conditions attach special importance to optional subjects. Special optional hours are provided for these subjects; there are some special classes and schools where some subjects are studied more deeply than others. These conditions provide a favourable atmosphere for covering achievements of modern science, technology and culture in the school programme with consideration of the peculiarities of every school. Thus, certain changes may be introduced without changing the main content of education of the common secondary school.

The selection of school subjects according to preferences and abilities of students helps them to gain knowledge independently and not only from the obligatory home tasks. As a result, students develop a steady interest in science and in certain aspects of practical activity; they are thus ready for self-education after they leave school. Selective studies allow the schools to exclude from the curriculum those problems which are not necessary for all students to be acquainted with.

At the present moment, schools have introduced dozens of optional curricula and curricula for special deep theoretical and practical study of certain school subjects. These cover various fields of the humanities, natural and mathematical sciences, art, literature, technical and applied sciences and practical work according to public demand.

The perfection of education content is closely connected with further improvement of the whole system of education, creating ever new forms and developing new methods of teaching providing for maximal development of cognitive activity and independence of students. This underlines the necessity of getting objective data about science and education to create and use an optimal complex of educational means, including new technical devices, to plan future perspectives of lifelong education of the people. The government has selected the most valuable achievements in science, engineering and art and found the best means of their demonstration at school, with the aim of inducing among students a search for knowledge and contributing to their intellectual, spiritual and aesthetic growth.

Carrying out the tasks of the Soviet schools demands complicated and many-sided activity of the whole scientific-pedagogic community. Not everything goes well at once and in compliance with the new ideas. Great effort has been required from the teachers to apprehend new ideas and new methods. In the course of practical work at school, it has become necessary to make certain corrections in the new education content. All this testifies to a gradual and thoughtful process of school reconstruction, as any hasty steps may negatively influence the further development of universal secondary education.

SECTION THREE

ASPECTS OF SCIENCE EDUCATION IN THE ASIAN REGION

Bulletin of the Unesco Regional Office
for Education in Asia
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SCIENCE EDUCATION IN THE RURAL ENVIRONMENT

by Rais Ahmed

Introduction

The scope, quality and methodology of science education is intimately related to our general concept of education and curriculum. It is also related to what we think of science itself. These would be trivial questions if there were not considerable difference of opinion as to what is 'education' and what is 'science', and if the traditional concepts of both had not recently undergone a great change. Happily, the emerging idea of education as an agent of national development and social change fits in very well with the new understanding that science is not only utilitarian or a means of harnessing nature for the well-being of man, but also a powerful factor for transforming man himself.

Obviously, one is faced with a series of complex problems here, and the approach to the new kind of science education is a major departure from the old. Some of the steps of implementation suggested may appear idealistic and almost impossible to undertake unless we develop a clearer picture of science education and search for action points which lead to a properly phased change.

Education for social change

No matter how we look at it, much of today's education is a narrowly conceived process. Its goals, for all practical purposes, seem to be the transmission of knowledge, its evaluation is mostly by a parrot-like repetition in an examination. It is confined to the book, the teacher and the school ; it is cut off from the real concerns of society, whether these are the necessity to produce more or to distribute better, or to solve local problems of shortages, health, housing, unemployment and so on. A child going to the school and studying his books with the teacher may even get an impression that all the problems that he hears about in his family and in the neighbourhood are an illusion. Education is generally formal, aloof and passive.

There is a theory that traditional education is intensely job-oriented, the job being clerical. In any case, school education is preparatory to college education, which is ultimately reached by a very small section of young people. At least in the developing countries, as we go higher up in education we find the higher income groups prevailing - and perhaps - this form of education is meant to filter-away the poor; it suits the elite who don't have acute 'problems', and in any case are more interested in maintaining the status quo than in social change.

The new form of education, on the other hand, is conceived far more broadly. It is meant to be in accordance with the life, needs and aspirations of the people receiving it. It is to be a lively and dynamic process striving to build a whole man and to lead to a just and open society in which the individual may not only survive but also flourish. In this concept of education one learns directly from study and observation of real-life situations, and one intervenes in altering these situations to human advantage. Educational policies and programmes thus are intimately related with the national goals of social, economic and cultural transformation.

We see therefore that the book does not remain the only source of learning, much of which now comes from experiencing - observing, studying living through and reacting to the life of the community. The school does not remain the only place of education which, it is now recognized, may take place in the fields and farms, in workmen's sheds, factories and homes. The teacher does not remain the only source of 'knowledge', in fact he becomes a facilitator of learning by guiding students to places and situations from which learning may arise, and by involving other resource persons in the process who can supplement the teachers' limited capabilities. The exclusive concern in the old system with cognitive development, and particularly with the convergent thinking aspect of it, is replaced with a balance of convergent and divergent thinking and of development of character, attitudes, values, outlook - a concern with ideals and culture. The intention is to cultivate an individual who is not only intelligent and knowledgeable, but also imaginative, critical and 'creative', who has a rational and humane outlook, and who is appreciative of beauty in its various forms. The entirely passive social role of 'knowledge' (equated to education) in the old system is replaced by an active role where the very purpose of studying a process or a phenomenon is to control it, and harness it in the interests of social development - a study of problems or needs and aspirations of people, in the new concept of education, must lead to a way of resolving the problems ; social change and progress must become a commitment and even a passion for the learner. This makes the teacher and the school an agent of change and development in our society, and it involves intimate co-operation with other developmental agencies working in the given regions.

The new approach to education is not merely a figment of our imagination. The developing countries in particular have evolved this approach in the course of their struggle for survival - the struggle to force the pace of development with meagre resources, to remodel elitist formal schooling to the needs of their people clamouring for social justice. Curricula based on approaches of this kind are being evolved and have been introduced in several countries. Much refinement is yet to take place and the feedback from the first experiences will inevitably lead to improvement - but undoubtedly education has taken a new turn.

New approach to science

The conventional meaning and scope of science in our curricula has been just as narrow as the meaning of education itself. If education has been equated to teaching for building up a stock of knowledge, science has been equated to the learning of some basic laws of physics, chemistry and biology. The ideas of the 'universal' nature of scientific knowledge on the one hand, and comparability of educational standards from country to country on the other, have been used to support teaching about a given set of plants, animals and situations in all schools irrespective of whether or not these are alien to the experience of children in a particular area. The fragmentation of science into a few disciplines like physics, chemistry and biology at the school stage leads to wide areas of even factual ignorance, where multi-disciplinary spheres such as agriculture, health or the environment are concerned.

But far more grievous than this is the gross distortion of the whole concept of science, in its intimate relationship with culture, and completely ignoring the method of science which is now being applied to so many other branches of learning. In the developing countries in particular, the traditional teaching of science degenerates into authoritative pronouncements in a bewildering variety of physical, chemical and biological descriptions.

The new approach to science is based on realism. Science is recognized to be a great creative activity of man, the achievements of which are seen in numerous discoveries and the establishment of the most beautiful unifying principles and theories. It is based on immense resourcefulness in design, flexibility in thought, far-reaching imagination and speculation, and a combination of reasoning and intuition on the part of its practitioners. The history of social evolution is inextricably dependent on and intermixed with the sequence of scientific developments. Science has therefore affected our very lives through the ages and its strands cannot be separated from the warp and weft of our culture.

On the other hand, the nature of science as it is today, in its finest detail, has been influenced by social factors. Science as natural philosophy went on to discover, and gave demonstrative proof of the fact, that the earth was not the centre of the universe and the heavenly bodies moved in paths other than perfect circles. This was heresy in the 16th and 17th centuries and scientists had to risk their lives for uttering these truths. That is how subsequently Descartes had to 'invent' the artificial 'primary' and 'secondary' qualities - the 'scientists' being confined henceforth to consideration of 'secondary' qualities only - such as movement, extension, colour, taste and smell, leaving aside other aspects of nature and society for the philosopher and the sociologist who could follow the path of 'pure' reason and speculation, sometimes without regard to experiment and reality. Developments since this early watershed between science and culture have tended to delimit the scope of science to the detriment of all learning. Then again, depriving science of a voice in social and human affairs meant a stress on the material aspect of science which was so aptly express by Robert Hooke in the draft preamble of the statutes of the Royal Society in 1663 "The business of the Royal Society is: to improve the knowledge of naturall things, and all useful Arts, Manufactures, Mechanik practices, Engynes and Inventions by Experiment - (not meddling with Divinity, Metaphysics, Morals, Politics, Grammar, Rhetorick or Logic)." This in turn was avidly taken up by the early industrial entrepreneurs and thereafter the paths along which science grew were governed more by considerations of what could be sold (to the man who could afford to buy) and be a source of profit rather than any concern for producing articles or know-how for the general good of society. In other words, science became commercial and devoid of any moral basis. It is such a science, free of considerations of conscience, which is propagated in our schools although this is far from the basic character of science which remains a pursuit of truth and an endeavour to conquer ignorance (and not nature) for the benefit of mankind.

A new approach to science must take into account the powerful scientific method with the help of which concrete results of science that we talk about with admiration were obtained and which is a method of far-reaching significance. It involves observation and experiment, classification and symbolization of data, intuitive as well as methodical, searching for patterns and correlations, of mathematical expression and generalization into hypothesis and imaginative design of new experiments or observations to differentiate between what is expected from the old and the new theories. The method implies that science is logical as well as intuitive, that it is systematic as well as speculative - but that above all it is open - hypotheses are open to change on the basis of argument, accepted 'facts' of yesterday are open to change on the basis of new evidence - and the more fundamental the change the greater is the credit to the investigator, contrary to what happens in many other disciplines and walks of life.

There is no authority to declare immutable or revealed truths, man and his researches are only the humble ways by which we can proceed step-by-step towards discovering what is not known. Science and its method therefore have not only a material side (which has been much emphasized so far) but a spiritual side. They are an integral part of human culture and they underline human qualities such as curiosity and creativity in place of passive learning by rote, willingness to adapt and change in place of inflexibility and dogmatism, challenge to think and speculate in place of blind faith and obscurantism, courage to stand by conviction in place of swaying with the wind. These qualities tempered with a sense of social justice, humaneness and appreciation of art and beauty could transform the personality of one who studies science and could be a great asset for social transformation in the developing world.

Thus we see that there is need to transgress the belief that science deals only with nature, and that its value is neutral or has no social purpose. Just a few decades ago education too was supposed to have no social purpose. The developing countries who are now engaged in refurbishing education to bring it in line with social objectives can hardly ignore the fact that science too is a great factor for social change, both material as well as cultural. Let science education therefore play its characteristic role in transforming man and his environment.

Science education in the rural environment

The first principle adopted in practically all developing countries is to make science compulsory in the primary school. In some cases all students take up science up to the tenth year of schooling. The second principle is to reshape the curriculum for science education keeping in view the need for national development and, in the case of the developing countries, rural development in particular, as also the potentiality of science for harnessing nature and cultivating in the individual what may be called the scientific temperament. The third principle is the relevance of the curriculum to local life and needs so that education may not have an alienating effect on the individual, dividing him from the uneducated and poor family, and pulling him away from the rural community, turning him into the unemployed and discontented youth of the towns. Lastly, of course, the changing mental and physical abilities with age have to be taken into account.

These principles convergently indicate that the best policy for the first few years of schooling when the child is from six to eight years old is to adopt 'environmental studies' as the basis of learning. Since this phrase is used in a variety of senses it may be explained that it means here an integrated approach to learning using the scientific method of observation, exploration, experimentation and reasoning. It is integrated both in the sense that the entire environment consisting of 'things and occurrences' - or the living, the non-living and their interactions - is within the scope, and that for the study of each element of the environment the sciences, social sciences and the humanities are at once fully involved.

In this environmental study, one could choose an 'element' like a tree, or a bird; or again a pond, a shop, or a bicycle; or a marriage, a death or a festival; or once again sanitation, cultivation or toddy making. In other words, in any given environment the starting point of the study could be any object, simple or complicated, or a social event, a process or a problem about which children may be naturally curious. The method of study would be through personal observation and involvement and the teacher would only guide the students in batches to make the observation comprehensive, searching and imaginative. The processes of scientific enquiry would be involved, and without the boredom of an explicit teaching students could imbibe the essence of the scientific method. Their understanding and experience of life around them would have been extended. They would be required to report systematically to the class what they had explored in order to learn the art of expression and discussion.

The insistence here is on an imaginative approach where the teacher may throw in a question about something which may not be directly observable - for example while studying a tree, the teacher may ask "how old is this tree?", or "how old are trees?", or he may draw attention to a side of the element under study which children may seem to be ignoring for the moment - for example are trees much good for human beings, or are they dead or alive ?

The teacher might like to raise a controversy by asking a question whether trees should be cut at all, (or any living beings should be eaten) and this may lead to moral and ethical as well as practical questions such as the balance of nature and the necessity of giving a well-considered response to exciting questions. The study might lead to experiments such as planting a seed and observing it grow, or seeing the effect of darkness on the life of a plant - or it may lead to a collection of leaves and flowers or a study of other things or processes.

It is to be noted that the approach which is being suggested involves in the traditional sense science and sociology, as well as the spheres of value judgement, philosophy and religion - and establishes the oneness of learning. In fact when any group of students will have studied the environment, starting from about two dozen different things or events over the course of two or three years, it would discover the interdependence of all things and the essential unity of the phenomena of our existence on the planet earth.

In the next stage of education for the child between the ages of 9 and 14 one may pursue the idea of environment-based learning but strive to go deeper into the scientific and technical side of it, leaving the mainly sociological side to be tackled by another group of teachers. The topics selected as the starting point should be the problems that beset rural life or are close to the experience of rural folk. This is a very important factor since it is at this stage that the traditional science curriculum begins to have a formal appearance, designed to lead a student on to the high school and beyond it to the college, and therefore stressing 'basic' laws.

Instead of the analytical approach, however, a functional approach to the teaching of science is being recommended. Problems such as those of food, nutrition, health, sanitation, housing, increasing agricultural production and crop protection should become the focus of attention. It is believed that not only will the relevance of the curriculum lead to better retention in the schools, but also those who terminate their studies at the end of the primary level will be left with sound, usable knowledge.

The investigation of the problems must again be broad-based and imaginative, not ignoring the social consequences and, in fact, emphasizing how man-made laws and customs sometimes create problems. Students should be allowed opportunities to discuss and reason so that solutions to some of the problems can emerge and there may be opportunities of collective or individual action to remedy situations. In some countries, students have studied individual plants in fields to detect unusual features of growth leading to recognition of plant diseases. They have by comparison of growth in different fields correlated growth with soil, watering schedules and the use of fertilizer. They have studied the state of teeth and cleaning habits and materials. They have studied food habits and child-rearing practices. In some countries, students have helped solve local problems like the provision of clean drinking water through the construction of cheap filters or sanitary latrines. These practices endear the children and teachers to the village folk and even lead to community participation in helping the schools. Further, the learners get an insight into many aspects of a problem which a person who had either grown in the atmosphere, or has walked into it after his curiosity has been subdued, might miss.

In the observation, analysis and practice through which they learn science, children may also learn to use simple tools and perform little jobs on materials. Special attention may be given to explaining the working of apparatus, machines and other technical facilities which are becoming increasingly accessible to village people. The old practice of leaving the study of technology until a student enters college should be given up and science and technology should be dealt with together. Only thus will students be prepared for the technological world of tomorrow.

A notable feature of science learning in this manner is that a minimum use is made of artificial situations (otherwise called the laboratory) and specialized items (called apparatus and kits etc.). First, most ofthe developing countries do not have the resources to buy the kits for all their rural schools and, second, teaching through kits has serious limitations since only very simple and idealized phenomena can be demonstrated which marginally contribute to the understanding of 'basic' rules as they are visualized in the present structure of the curriculum. Obviously learning of science through exploration of real-life problems, situations, events and things cannot be accomplished through the kits.* The following of the whole gamut of the scientific method and looking at complex phenomena involving both man-made and natural situations is likely to cultivate a scientific attitude and an understanding of the relationships involved.

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* For a contrasting viewpoint the reader's attention is directed to the article on producing low-cost science equipment.

A very desirable possible feature of science education in the later years of primary schooling; i.e., between the ages of about 11 and 14, is the involvement of students in the production of certain simple articles in the schools. This goes under the name of 'pre-vocational' education in some countries and 'work experience' in others, but it could be very closely related to science education. The purpose of this activity is to cultivate an attitude of ready acceptance towards manual work and working people, so that the elitist and white-collar impression of education on young minds is remedied, and also in order that some technological skills may be acquired by students. But the activity can form a composite part of science education because of its potential in actual production of articles of common use in the school, and since refinement of local technologies can possibly be brought about in this manner. Chalk, dusters, file covers, and many other articles made of textiles, wool, wood and local fibres, and used in homes, schools and the community, can be manufactured. This results in some income for the students, and the schools, which latter can be ploughed back in improving the production facilities.

Since, in the under-developed countries, education has to compete for funds against sectors which involve immediate relief and services for the people, it will be a great change if education produces some resources for its own development. Therefore, production activity in schools and school participation in agriculture, horticulture or fish culture is always most welcome, and indeed in quite a few developing countries this has been taken up to a significant extent. For each article produced, or for agricultural practice or participation in any other rural development activity, science education must play its part by deepening the understanding of the processes, and what is even more important, improving the processes, effecting economies, suggesting alternate designs, even inventing things to satisfy local need.

A reasonable suggestion is that science education in the functional sense, based on real problems which one comes across in rural communities (and likewise for the urban areas) should continue for all students until the age of about 16; only after this one may reorganize it in the form of disciplines and try to elicit important basic principles; i.e., formalize what has been learned so that the formalism itself, through mathematics in particular, may yield further knowledge.

Science education conceived in the manner discussed here seems to be in accordance with the nature of the scientific process itself, and it would contribute to rural development, but the curriculum has to be worked out very carefully, especially because no models exist. Environmental education material for the youngest children will have to be developed to help the teachers who live in different social and geographical regions. Integrated science material of local relevance will have to be produced for students as well as teachers and will have to be visualized starting from a discussion and observation of local problems and activities.

Today's science graduates who have been brought up in split-disciplines and a formalized atmosphere of science, and who are not even aware of the rural scene and its problems, will not be able to handle classes in the schools without re-orientation. Undergraduate education and teacher education will have to be altered so that the new programmes may be smoothly put in operation. However, a feeling of optimism is generated, in spite of the problems, since the concomitant tasks have been delineated and the new approach is being implemented at all levels in some countries. Then, beyond the age of about 16 years, science education plays a direct role in rural development through programmes of vocationalization. Here the local needs of small-scale industry and services, or a potential for pressing into service under-utilized resources, such as agricultural waste, leads to the finding of lifetime occupations, and to the care and conservation of our precious natural resources.

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WHERE IS EDUCATION GOING?

by A.R. Kaddoura

From a lecture given by the author at the International Conference on Physics Education, Edinburgh, 29 July-6 August 1975.

May I first of all say how grateful I am for the opportunity of addressing this distinguished gathering of scientists and educators. The decision to have a plenary meeting on the general theme of "Where is education going?" is a clear indication of a general awareness of the need to devote some thinking to the wider picture of our educational activities. This is particularly fitting for men and women whose discipline is always striving to proceed from the particular to the general, and whose activities tend constantly towards more and more unification of concepts and phenomena.

My modest contribution is a product of my work as a science teacher and educational administrator in Syria, of some experience gained in regional educational activities in the Arab homeland and particularly of the lessons I have learned as a member of the International Commission for the Development of Education. This Commission was established by Unesco in the early months of 1971 and its report was published towards the end of 1972 under the title Learning to Be. It was presided over by Edgar Faure, at present Speaker of the French National Assembly, who has had a distinguished career, having twice been Prime Minister of France and having had the difficult task of Minister of Education in the turbulent days following May 1968. The members of the Commission came from various regions of the world, allowing for each aspect of the political, economic, ideological and intellectual makeup of the international community. It is in the capacity of a scientist among the members of the Commission that I have been asked to deliver this lecture.

This present conference is a direct manifestation of the fact that educational techniques are changing and that efforts for their improvement are pursued in many parts of the world. But is humanity devoting a comparable effort in its search for a 'newer education' to that in the fields of scientific investigation? The answer is clearly No, and this is one of the reasons for the profound malaise felt by so many national educational systems. In many countries of the world, educational systems

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that evolve in response to conditions of slow change and rigid social stratification are painfully struggling to adapt themselves to societies characterized by rapid change and an ever deeper aspiration towards democracy. This conflict is nowhere as acute as in the countries liberated from colonialism and which inherited educational systems designed for, and capable of coping with, a minute minority of young people. These countries found themselves, after independence, faced with a completely new situation in which their educational systems were required not only to accommodate an ever increasing fraction of the young population but also to train young people to meet the infinite variety of intellectual and technical paths vital to the economy of the modern state.

The learning society

Under this tremendous challenge, their defence—presumably the only one available to them—has so often been to scale up the inherited system to allow it to absorb more and more young people. But neither sufficient intellectual effort nor appropriate material resources were devoted to the exploration of original ideas and methods to meet the new conditions in time. The new independent countries could not do it, not only because they lacked sufficient resources to allocate to the task, but also because they fell victim to the complacency prevalent in the old colonial past and to the belief that well established educational ideas had proved their worth and could and would steer the new countries towards progress and affluence.

The crisis that continued throughout the 1950s and early 1960s eventually came to ignition point in the late 1960s with the student movement which struck at many parts of the world. Since then there has been much heart searching among people interested in one way or another in education, and an old idea has been steadily gaining ground, being reinforced by subsequent educational developments and assuming in its expression various forms, some very radical and some less so. This idea is that the concept of traditional skills (i.e. the concentration on the process of acquisition of knowledge and skills in a sharply defined special and temporal domain) is a concept that must be transcended.

Some of the more radical critics of the schools go so far as to advocate deschooling society; others, less ambitious or perhaps not so reckless, believe that more forms of educational activity must be developed within and outside the schools in such a way as to approximate gradually to an ideal situation where education becomes a purely social activity, and in which every member of society engages in learning throughout his active life. The advocates of this approach—that of the 'learning society'—maintain that this idealized state will be long in coming. But in our changing world few things are as Utopian as they may at first seem, and something tending in this direction becomes more and more mandatory as time goes by.

The concept of lifelong education—which is the cornerstone of this learning society—has a considerable ancestry. It was put forward by various great civilizations (the Greeks, the Chinese and the Arab Muslims among others), sometimes as an abstract ideal to be desired and sometimes as a practical gain to be implemented. The essential difference between the old idea and its modern expression is that the former was the exclusive prerogative of a restricted minority of well-to-do, an elite in society which could devote itself to this continuous process of learning. The members of the elite could afford to do this because they were maintained by the working masses or by slaves or freemen who supplied them with the necessities and luxuries of life.

International problems of education

The learning society of tomorrow, if and when it becomes a reality, will not be, and could not be and should not be, that of an elite, but the collective venture of all the people. It remains to be seen how this is going to be achieved, and whether it will be possible to break the 'artificial divorce' between learning and doing, between educating oneself and others and using the results of this education for practical means. This is one of the greatest challenges offered today to humanity. A solution will not be easily found, and great resources will have to be devoted to it. But there does not seem to be another alternative to present-day educational practices, which are becoming more and more unrealistic and divorced from reality and the requirements of our time.

Difficulties in education are particularly acute in the developing countries. Is this because something fundamentally different is occurring in these countries? Or is it rather that the shortcomings are present everywhere but are particularly inherent and exhibited in the developing countries, which act as a kind of magnifying glass? The available evidence seems to favour the second alternative. One of the most useful lessons the international commission has learned in its 18 months of activity is that of the unity of the world of education: unity within diversity, to be sure, but unity nonetheless. It was quite remarkable for us to see that problems arising in an affluent country, having a long liberal tradition in the field of education, were fundamentally similar to those encountered in a new country having only recently acquired the status of independent nation and still struggling with tremendous difficulties and scant resources to solve the problem. There were differences to be sure, but these were differences in intensity and not in kind. The feeling of urgency in face of these difficulties and the conviction that only active international solidarity could lead to their solution are two of the most widely accepted facts. I would like to survey very rapidly some of the problems and to ask the questions they raise. I will classify them under five headings.

The education explosion

The first class of problem concerns quantitative questions. A common characteristic of contemporary education is the tremendous expansion of student numbers throughout the world and the resulting increase in educational expenditure. Our world, which is experiencing a population explosion, is also—and partly because of it—experiencing an education explosion. Let me briefly mention a few figures to illustrate this trend. From 1960 to 1968 the world's population increased from just under 3,000 million to almost 3,500 million human beings. This was a jump of 17% in eight years; an annual growth rate of just under 2%. During the same period the world's total school age (5-19 years old) population rose from 955 million to 1,150 million, an increase of approximately 20%, with an annual rate of increase of 2.35%. This is a rate nearly 20% higher than the world population expansion rate. For the remaining years of this century predictions are that the number of people of school and university age will increase by more than 1,000 million. This represents an annual average increase of 36 million potential pupils and students.

The proportional provision for education in state budgets is generally rising. By regions, increases between 1960 and 1965 were as follows: from 13.5% to 16.4% in Africa, from 15.6% to 17.6% in North America, from 12.6% to 15.4% in Latin America, from 11.8% to 13.2% in Asia, from 13.5% to 15.0% in Europe and the Soviet Union, and finally from 10.4% to 15.7% in Australasia. On the world level the proportion of national budgets allocated for educational expenditure rose from 13.5% in 1960 to 15.5% in 1965. At present, it is probably about 16.0%. Many countries in the world are already at or near the saturation point in their ability to increase expenditure on education. A slowdown in the rate of increase has been clear in several developing countries, although the needs are still pressing. It is in many of these countries that the present traditional education system is still unable to accommodate a sizable fraction, and often the majority of the young generation.

Some figures will again illustrate the present situation. In 1950 there were 700 million illiterates in the world: 44.3% of the total population. By 1960 the number had risen to 735 million, although the percentage as a fraction of the total world population had gone down to 39.3%. By 1970 the number, still rising, had become 783 million—but the percentage had decreased to 34.2%. It is thought that in 1980 there will still be 870 million adult illiterates and a world illiteracy rate of 20%.

If industrialized countries have already practically achieved universal primary and secondary education, they seem to be now in the process of the third educational revolution: that of universal higher education. The USA, among the market economy countries, and the Soviet Union and the GDR, among countries with centrally planned economies, are already well engaged in this process, and may be followed before long by other affluent societies as indicated by the expansion in higher education in many industrialized countries. If and when universal higher education is achieved, why not universal post-higher education, for which a new word will have to be coined. And where will this process end? It is clear that each country will reach a saturation point somewhere along this spiral, a point beyond which it will not be practically possible to go. Many of the poorer countries have already got dangerously near to it, with the social tensions and frustrations that this entails.

Already in many countries one person in five—and perhaps in some countries one person in four—is at school doing something. Even industrialized countries are experiencing difficulties in coping with this situation. If the situation in the developing countries is so much more severe, this perhaps will remind us of what Marx wrote about the fact that if a country wanted to know its future it had only to look at the present state of the more advanced countries. Could we paraphrase this and say that if a country wants to know its future educational difficulties it has only to look at the difficulties of the less affluent countries?

Education and elites

I come now to the second class of problems, those of a social nature. Education has often been called the great social equalizer. If this idea has often proved true in many countries—particularly in young ones—and in periods of social upheaval and tumult, it has also often been challenged in very many instances. It appears from casual inspection, as also from the systematic studies which were pioneered in the USA, that, in more or less stable established societies, traditional education, far from always being an agent of social mobility and fluidity, often acts as a factor conductive to social stratification and into perpetuation and amplification of social privilege. As with the first category of problem, this aspect, although common to both developing and developed countries, becoming strikingly apparent in the case of developing countries. In their environment the magnifying glass effect enhances it. Education is becoming more and more the breeder of the leading sector of society and is in this way replacing previous mechanisms of class, religious or ethnic character. It might be expected that the more or less hereditary character of the leading sector of society will wither away and disappear.

Present evidence does not support this optimistic view and tends on the contrary to suggest that the more educated people tend on average to have more educable descendants than less educated people. This trend appears to be widely spread. It can be encountered in western countries, for example, where many experiments in further education, usually specifically designed for the less well endowed, have ended by benefiting those who had already much benefited from traditional education. A similar situation obtains in developing countries, where the educated elite, formed during the struggle for independence or immediately after it, has tended to produce a sizable proportion of the subsequent leading generation. Even socialist countries, where specific measures were enacted immediately after the social revolution to enforce a fair representation at the various educational levels of the masses of the people, do not seem to be entirely immune from these symptoms.

In summary, it seems to be true that education attracts more education and that a child reared in an educated environment is more educable than an equivalent child reared in a less educated family. This fact does not seem to be a transitory, pathological symptom of traditional education but is presumably a natural characteristic stemming from its intrinsically elitist nature. Education has inherited this characteristic from its long past and clearly displays it in its perennial inclination to competition and selection. Examinations are but one manifestation, among others, of this disturbing fact.

Any step towards the possible realization of a learning society will have to have the cure for this defect and devote more effort to those whose background—whether social, ethnic, racial or otherwise—presents them with a handicap in their educational struggle. This shying away from sheer efficiency towards more justice is already apparent under various guises in many countries of the world and is a positive sign on the long road towards a truly collective effort in education.

Education and employment

I come next to the relevance of contemporary education as a preparation for a life of work and production. Here again we find the magnifying glass effect in operation. In many rich countries there are already young men and women failing to find the kinds of jobs they were trained for. The extent of this phenomenon is, however, far from being comparable with the graduate unemployment in a developing country, which is growing fast to alarming proportions. But the same symptoms exist albeit in different degrees. In the USA the number of young unemployed Ph.Ds in physics, chemistry and other fields is growing. And bitter complaints by the young against their elders are often voiced in professional journals. Some pessimists maintain that the 1970s will be the decade of graduate unemployment.

Until now the phenomenon of general unemployment in the affluent countries has remained reasonably under control. But not so in the developing countries, as some of the following figures show: The percentages of unemployed in urban areas have reached 13.6% in Bogota, 17.9% in Venezuela, 15.0% in Sri Lanka, 9.8% in Malaya, 11.6% in the Philippines, 14.9% in Kenya, and 11.6% in Ghana. The average level of education among the unemployed is rising: the notorious case is of course that of Sri Lanka, where some of the figures cited by W. Sears in his report to the ILO are really staggering. He mentions that in the age group of

15-19, 92 % of adolescents with GCE O-levels are unemployed, whereas the ratio in the same age group is only 38 % for those who have not obtained GCE O-levels. So this certificate appears to be a very good insurance against employment.

This aspect of education, which is intimately connected with its economics and efficiency, has been attracting much attention in many countries. The study of education from an economist's point of view is not a new approach—it was already present in the writing of the classical economists and of Marx and it received much attention in the early days of the Soviet state. It has since been actively pursued by many scholars. Schultz and others in the USA have devoted a lot of thinking to the subject and have given it new vigour and fervour in the conditions of the west. The debate that has gone on for a long time on whether to consider education as investment or consumption will clearly be greatly influenced by the new phenomenon of graduate unemployment on a massive scale. Here again it would seem that purely economic considerations would lead us to search actively for new forms for the educational process, which would raise its economic efficiency and also enhance the human dignity aspect.

Even within the present limits of traditional education a hard look at the economic motives behind much of present day educational demand is necessary. It is well known for example that private rates of return on investment in education are amongst the highest available to an individual. This must be contrasted with the fact that in modern conditions most of the expenditure on education is of social origin. One obtains the paradoxical result that the individual has a strong economic incentive to climb always higher on the educational pyramid, even against his personal inclinations and in this regard his potential. This is never so true as in poor countries, where a degree or a diploma is often the sine qua non for social promotion and economic wellbeing.

This phenomenon becomes particularly acute in conditions where unemployment among the educated is spreading. In these conditions failure to secure suitable employment, after the completion of any particular educational stage, acts as a strong incentive for the individual to proceed to the next higher stage in the hope that there at last he will be able to land the job that had been eluding him. In many countries of the Third World, there are instances of this shadow hunting. Any fundamental reform of traditional education will presumably have to decouple education and income, which are at present very strongly correlated. How this is going to be done is another matter and it certainly raises difficult social and economic problems, particularly in the developing countries.

Is education fun?

I come now to the fourth class of problem, those of a human nature. Every day sees increasing numbers of children and adolescents engaged in education. But how many of these are really enjoying it? How many are loathing the constraints imposed upon them by adults? How many are accepting it, if at all, for no other reason than sheer resignation and the belief that this is the only way of decreasing the hardships of their future adult life? What effect is education producing in the young generation through this atmosphere of constraint and tension? In 1932 Bertrand Russell wrote in his Education and Social Order:

"Compulsion in education destroys originality and intellectual interest. Desire for knowledge, at any rate for a good deal of knowledge, is natural to the young but is generally destroyed by the fact that they are given more than they desire or can assimilate. Children who are forced to eat acquire a loathing for food; and children who are forced to learn acquire a loathing for knowledge. When they think, they do not think spontaneously in the way in which they run or jump or shout: they think with a view to pleasing some adult and therefore with an attempt at correctness rather than from natural curiosity.

"The killing of spontaneity is especially disastrous in artistic directions. Children who are taught literature or painting or music to excess—or with a view to correctness rather than to self expression—become progressively less interested in the aesthetic side of life. Even a boy's interest in mechanical devices can be killed by too much instruction. If you teach a boy the principle of the common pump in lesson time, he will avoid acquiring the knowledge you are trying to impart, whereas if you have a pump in your backyard and forbid him to touch it he will spend all his leisure touching it.

"A great many of these troubles are avoided by making lessons voluntary. There is no longer conflict between teacher and pupil and, in a fairly large proportion of cases, the pupils consider the knowledge imparted by the teacher worth having. Their initiative is not destroyed because it is by their own choice that they learn."

Can one ever attain this ideal whereby learning is fun, a kind of game to be enjoyed, and where the initiative of the learner is given full rein? Can learning be transformed into a spontaneous process, not unlike the acquisition and gradual mastering by a very young child of his mother tongue? And how could this freedom be reconciled with the necessary self-discipline that seems to be inevitable for almost of learning? To put it crudely, how could the learning of the multiplication tables, assuming that it is still useful or necessary, be made an enjoyable act? How near are we to finding the answers to these questions that educators have been asking themselves for generations?

Could we, to end this section, describe our present predicament with what Whitehead wrote:

'In the history of education the most striking phenomenon is that schools of learning which at one epoch are alive with the ferment of genius, in a succeeding generation exhibit merely pedantry. The reason is that they are overladen with inert ideas. Education with inert ideas is not only useless: it is above all things harmful. Every intellectual revolution which has ever stirred humanity into greatness has been a passionate protest against inert ideas. Then, alas, with pathetic ignorance of human psychology it has proceeded by some educational scheme to bind humanity afresh with inert ideas of its own fashion'.

The curriculum barrier

I come lastly to the fifth class of problem, that of content of curricula. I would like to examine briefly the way many of our educational systems atomize knowledge and present it in a piecemeal fashion. The development of science seems to proceed by a dialectical process of the subdivision of a discipline into branches to be followed by subsequent unification, followed itself by new subdivisions, and so on. Traditional education on the other hand seems to have a particular fondness for keeping the branches separate and apparently without connection. How many years after the mutation of electricity and magnetism into the beautiful electromagnetic theory of Maxwell did schools continue to teach the two subjects as utterly separate and independent?

The same trend towards keeping related branches in sharply separated compartments appears in the rigid barrier established by our curricula between the natural and the social sciences. It is true that we may still be far from the ideal of Marx when he wrote 'The natural sciences will one day incorporate the science of man: just as the science of man will incorporate the natural sciences. There will be a single science'. If this ideal is still in the future, many signs indicate that we are moving in that direction through all the interdisciplinary studies that are cross-fertilizing scientific investigation. But this unifying trend is greatly hindered in its diffusion throughout our educational system.

Another aspect of this tendency to fractionalism is the barrier that has been artificially created between science and technology in our curricula. A hierarchy is often established in the school whereby science comes uppermost with technology a close second. Even within science itself such a caged system is frequently imposed. We continue in this sterile fashion although we know better and have known it for a long time. Even in 1929 A.N. Whitehead wrote:

'The antithesis between a technical and a liberal education is fallacious. There can be no technical education which is not liberal, and no liberal education which is not technical. That is, no education does not impart both technique and intellectual vision'.

In conclusion I would like to summarize my main points. It would seem that past trends in education, which keep on reproducing its structure on a continuously increasing scale, will sooner or later come to an exhaustion point. This point will be attained in different countries at different stages. But it seems nonetheless to be a universal barrier. The constraints which make up this barrier are of a social, economic, human and practical character. Only intensive and sustained research will make it possible to find new ways and means of starting on the long journey towards the learning society.

The ultimate hope will be an organizational structure where every individual will be able to fuse into harmonious mixture the three components of his active life—those of work, learning and leisure—in such a way that these three components become but the three facets of a single unit. Such research, to be successful, will have to be undertaken on a worldwide basis and benefit from the collaboration of many educators of this world. The problems that are facing education are universal in their essence but infinitely different in their manifestations. They can only find their solution in a universal approach having infinitely many ramifications. I will conclude by quoting from a text jointly written by five eminent educators coming from five different countries:

'It should be recognized now by all—and not by governments alone—that world educational needs require continuous patience and expanding effort in men, money and resources on the part of nations, and in international co-operation for the remainder of this century. This will involve hard work by all concerned, a readiness to learn, adapt, evaluate and adjust programmes and techniques, and a commitment to build a peaceful world community based on international understanding, social justice and progress towards a more abundant life for all'.

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for Education in Asia
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SCIENCE CURRICULUM DEVELOPMENT IN THAILAND

by Sukhum Srithanyaratana
Nida Sapianchai
Gordon Aylward

Although this article describes a particular science curriculum institute, the authors generalize helpfully in some areas, particularly in the later pages. It is thought that by adding the descriptions of the project in the Thailand article on pages 164–175 to the history and analysis here, readers may make their own comparisons to serve as a reference for the development of a science curriculum centre.

Science is doing - a very simple slogan on which to base school science curricula, immediately understood and often accepted without a second thought, yet these three words describe the dramatic change that is taking place in the teaching of science in the schools of Thailand. The instruments of change are all at hand: a new book for every student, in-service training and a guide book for every teacher, ample supply of science equipment for student use, most now made in Thailand, biological specimens deliberately chosen from the school surrounds and, for the lab, locally produced chemicals or those inexpensively imported in bulk for industrial use.

Biology teachers repairing microscopes during in-service training in repair and maintenance of equipment

Science in Thai schools need no longer be a subject more akin to badly taught history where the boredom of learning outmoded science information is broken only by the tedium of balancing ridiculously unreal chemical equations or doing sums in physics calculated to umpteen decimal places. The processes of science need no longer be destroyed by the method of teaching. Now, in the classroom, science can be doing and students can learn by doing science.

The students' books are not textbooks in the traditional sense, they are invitations and guides to discovering science. Facts there are, but there are also many challenging questions asking the students to find the answers.

Much of the science comes from tropical Thailand. Studies are made of Thai ecosystems, population growth of urban and rural Thailand, diet and nutrition, Thai chemical industry, rice farming and the physics of the rice mill, the sources of power and the national transmission network. Material is also adapted from proven texts on universal topics such as chemical bonding and periodicity, on electrostatics and concepts of energy, on digestion and respiration.

While costs at present prohibit the introduction into the schools of the latest techniques of educational technology, they are being used extensively to illustrate the new teaching methodology in the teachers' colleges and in the training programmes for in-service teachers. Model lessons are televised, video-tapes demonstrate new laboratory and field techniques, management methods for 50 children carrying out their own experiments are shown and, for use in the intensive three-week, in-service summer training programmes, science movies have been dubbed in Thai and self-instruction narrated slide sets and 'flip books' prepared.

All the changes would fall on barren ground if the examinations remained the memory tests of the past. Examinations are being developed that reflect the curricula's spirit of enquiry and test logical thinking, problem-solving ability and application of principles.

These new curricula are the culmination of a number of years of carefully planned development and co-operation on the part of the Thai Government and its Ministry of Education, UNDP and Unesco, teachers, college and university lecturers, international consultants and many other groups from industry, agriculture and the community.

The establishment and organization of the Thailand Institute for Promotion of Teaching Science and Technology (IPST) is described on pages 166 and 167 of this Bulletin. More details of the work of the IPST are given in the pages that follow.

Curriculum design teams

A design team was chosen for each subject area to be developed, one for chemistry, physics, biology, physical science, mathematics, and general science. The teams were made up of classroom teachers, supervisors, teacher training college instructors and university lecturers. In addition to a full complement of competent nationals each team was assisted by a Unesco consultant provided through UNDP assistance.

The leader was the key person in each team. Initially, three leaders were chosen from subject specialists in colleges of education, one from a university and one from a technical college. Later, two teachers and a Ministry supervisor took over the leadership of teams. As work got underway other teams were formed to provide technical service to the design teams, the teacher training unit (later the 'educational innovation unit'), the equipment workshop, the public relations unit, the evaluation unit and the stores and distribution unit. Although each design team enjoyed a reasonable degree of independence, their work was co-ordinated by the Director, the Deputies and the IPST Advisory Board which was made up of leaders of the design and service teams.

Experienced teachers try new experiments during in-service training

The international staff recruited by Unesco has in the main the role of advising and supporting and occasionally giving guidance to the national staff who carry out the actual work of developing the curricula, writing and re-writing the textbooks in the national language, and designing and producing the equipment. This supportive role of the international staff is emphasized by the pattern and type of the expert services provided under the UNDP assistance. During the first two years of the project, when the Institute was being organized, the senior national staff undertook short study tours while other national staff were given advance training of one or two years locally with the help of Unesco experts. Later, a number of short-term Unesco consultants were brought in to advise on specific subjects. This project design was made possible by the number and quality of the national staff and by the creation of an infrastructure which could make good use of the high-level consultants in developing the project. The quality of the staff was enhanced through international and local fellowships, care being taken that the fellowships abroad normally took place in institutions where the Unesco consultants were coming from.

The curriculum and its development

The initial decisions concerning the overall theories and organization of the new curricula were made after conducting seminars and after the teams completed intensive studies of materials which had already been produced in other countries. Although the curricula have not followed any particular curriculum from another country it should be pointed out that writers have drawn from many in attempting to develop Thai-oriented modern science and mathematics programmes for the lower and upper secondary schools.

The upper secondary M.4 and M.5 courses in physics, chemistry and biology (grades XI and XII) have evolved from the courses introduced in developed countries in the mid-1960s. The IPST courses, however, take account of changing times and include applications of science principles to problem solving and decision making on matters of current concern to the students and Thailand. Nevertheless the courses are designed to interest science-minded students. They are set at a depth that should be intellectually stimulating without being difficult for the student of slightly above average ability. They remain basically discipline-oriented and conceptually-planned. They are essential ingredients of a grade XI and XII education programme for future scientists and technologists.

Running parallel with these courses is the IPST interdisciplinary course in 'physical science'. The course materials are presented in modular form, each rated at one-semester credit; 12 modules are planned at the present. This course is offered as an alternative to the discipline sciences for grade XI and XII students, although in the future some modules may be suitable for students who take only a portion of the total discipline-oriented courses offered. The modules are topic-centred providing a broad coverage of science of relevance to the educated citizen. Later, some modules centred on basic concepts needed for solving problems may be developed to give greater challenge to the students of higher ability.

The M.1 to 3 (grades VIII to X) general science course is an integrated science programme divided into six semesters. The first two semesters are concerned with the science of the world around us, the next two take energy concepts as the integrating theme and the last two focus on the environment of Thailand, attempting to point to the need to balance agricultural, industrial and population growth with the sensible carrying capacity of the nation's natural resources and environment.

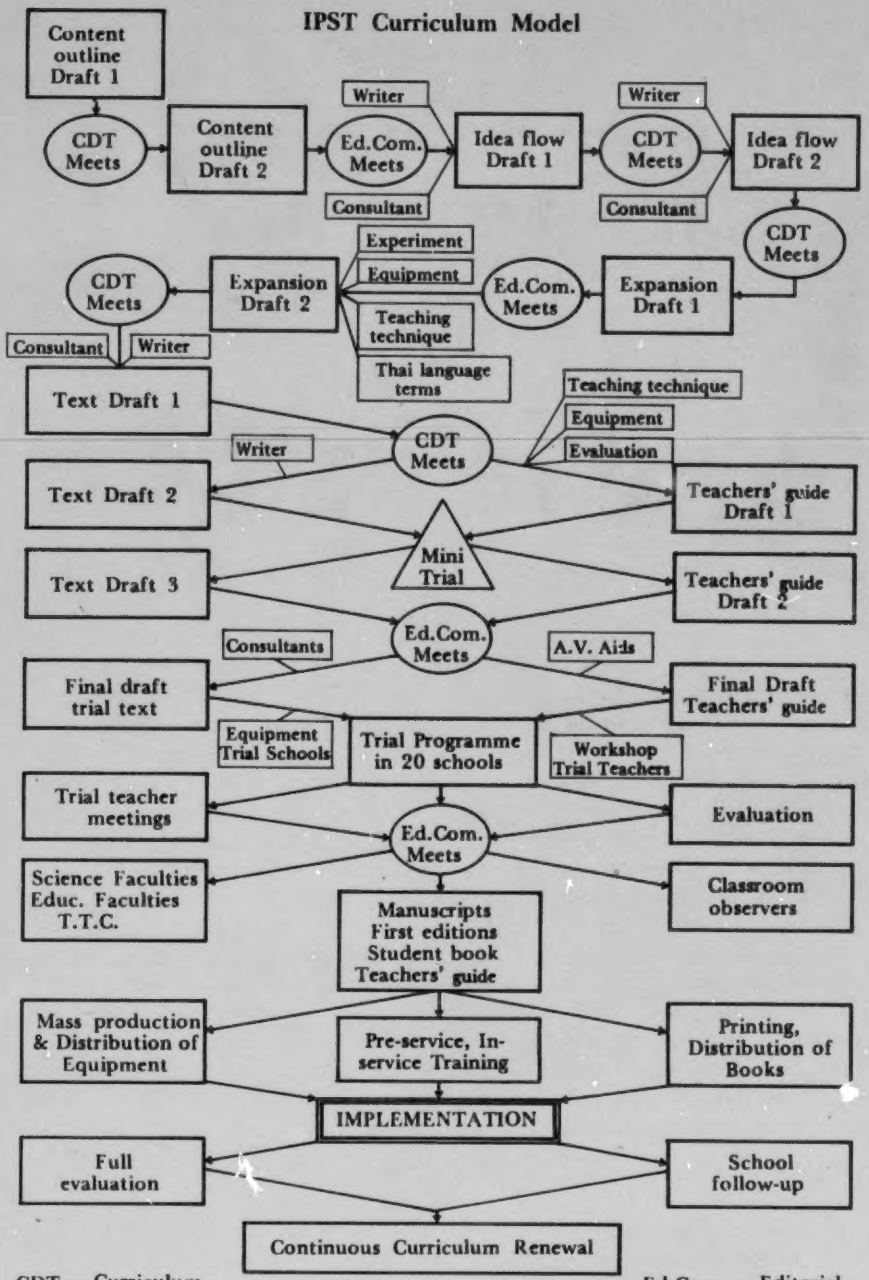
These courses are interest-motivated, and involve students in doing science, and in identifying problems and looking for methods of solving them.

Students making an experiment in a "mini-trial" at IPST

Mathematics curricula have been developed for students from first grade of primary to the final grade of upper secondary school. Most of the basic topics remain in the new primary courses but the teaching techniques are different, and more concern is shown for the children's learning processes. Drill there is - but drill follows and does not replace understanding. In the lower secondary courses, students are encouraged and guided to exercise thinking and to find solutions to problems that interest them. (Mathematics becomes an elective course after grade IX). In the upper secondary (grades XI and XII) all the branches of mathematics are integrated into one course designed around the structure of mathematics. Students may elect either a two- four- or six-credit course. The mathematics curricula may be thought of as 'second generation' curricula for they have been developed following the outcries about the 'new maths' courses in other parts of the world. IPST courses are a blend of the old and the new. They are built on the structure of mathematics but they do provide a balance of arithmetical and algebraic manipulative skills with logic, proof, analyses and some rigor.

The science and mathematics courses when fully functional in the nation's schools will provide students, particularly at the upper secondary stage, with adequate choice in curricula to satisfy their interests, aspirations and abilities. The IPST curriculum model, shown in the diagram on page 208, illustrates how the concurrent developments are integrated into the curriculum production schedules.

IPST Curriculum Model


Content outline Draft 1
CDT Meets
Content outline Draft 2
Writer
Ed.Com. Meets
Consultant
Idea flow Draft 1
Writer
CDT Meets
Consultant
Idea flow Draft 2
CDT Meets
Expansion Draft 1
Ed.Com. Meets
Experiment
Equipment
Teaching technique
Thai language terms
Expansion Draft 2
CDT Meets
Consultant
Writer
Text Draft 1
Teaching technique
Equipment
Evaluation
CDT Meets
Writer
Text Draft 2
Teachers' guide Draft 1
Mini Trial
Text Draft 3
Teachers' guide Draft 2
Ed.Com. Meets
Consultants
A.V. Aids
Final draft trial text
Final Draft Teachers' guide
Equipment Trial Schools
Trial Programme in 20 schools
Workshop Trial Teachers
Trial teacher meetings
Evaluation
Ed.Com. Meets
Science Faculties Educ. Faculties T.T.C.
Classroom observers
Manuscripts First editions Student book Teachers' guide
Mass production & Distribution of Equipment
Pre-service, In-service Training
Printing, Distribution of Books
IMPLEMENTATION
Full evaluation
School follow-up
Continuous Curriculum Renewal

CDT — Curriculum Design Team

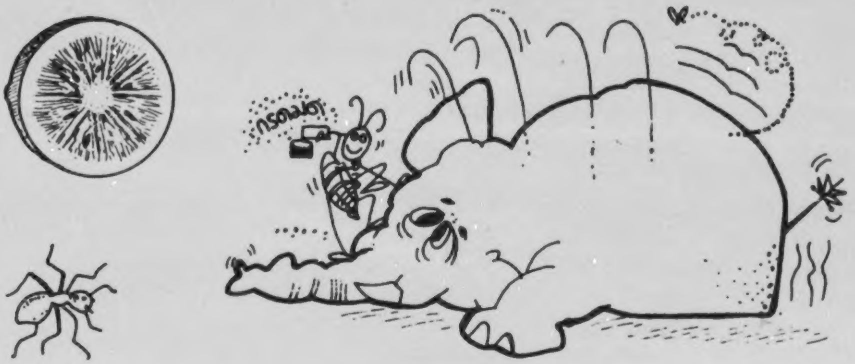
Ed.Com. — Editorial Committee

Feedback and revision

Feedback for improvement and revision of the curriculum comes from several sources. First and foremost are the trial teachers' comments. These are given in writing and verbally at weekend meetings. Also formative (the end-of-chapter tests) and summative tests are administered to the trial classes and marked by the teachers at weekend meetings. The test items are analysed and the results discussed with the teachers at their next meeting to decide whether a high difficulty rating highlights a curriculum problem.

Most teams agree that the most useful feedback comes from the trial teachers' meetings. Here the teachers either support or disagree with one another. The extent of the problem can be assessed from the group's support, and the relationship to the ability of the teacher and the students can also be gauged. In regard to the analysis of test items to highlight curriculum problems, it is found to be a useful and valuable exercise for both design team members and trial teachers. Also, in reviewing the examination papers each item is discussed and rejected or revised. By this process, expertise in test-item writing is gained and the quality of test items increasingly improved.

Like every other project around the world, the acceptance level for feedback varies considerably among individuals. The same feedback data have been interpreted as support for opposite opinions in a number of cases, but team members do make a genuine effort to use feedback - and a great many improvements to the students' books, teachers' guides, supplementary materials, and the science equipment have resulted from teachers' and students' suggestions.



"Acid in the bite of an ant"—an illustration from a students' text/workbook

Products of curriculum development

The students' books contain many activities and experiments around which questions are asked and the students find the answers from observation and from analysis of experimental results. The questions are constructed after analysis of the mental and manual operations required to develop scientific and mathematical concepts. The questions guide the students' learning and place them in the role of 'discoverer'. The teachers direct the operations, control the pace and provide assistance when a student or group gets 'stuck'. Equally important, they also consolidate areas of the subject into formal presentations. The students' book is not a text in the traditional sense but a guide to learning, a new learning in which the learner generalizes and formalizes from the specific and informal, instead of the converse as done in the past.

The teachers' guides complement the students' books. They give the teacher additional background material and information on pacing the programme, and on the advance preparation necessary for each experiment. The guides suggest outlines for pre- and post-lab discussions and illustrate how the major concepts in the course might be linked together. The guides also contain many test items that have been tested in the trial schools. They then set out the method of writing items and encourage the teachers to write their own items for assessing their students' achievement.

Before the introduction of IPST courses, much of the science equipment was imported. Now 80% of the equipment for the new curricula is made in Thailand. IPST has its own workshop in which the prototypes are designed in consultation between the workshop staff and the curriculum developers. The prototypes are tested in the trial schools and subjected to the same evaluation and feedback as the students' books and teachers' guides. (About 20% are re-designed between first and second trials). The trial class of 45 children is divided into 15 groups for laboratory work so 15 sets of equipment make up a classroom set, and since there are 20 trial schools for each subject, at least 300 sets of equipment are needed for the trial schools. Classroom sets are also distributed to the regional centres, teacher training colleges and universities. Including sets for replacement and in-service training usually about 400 sets are made in the IPST workshop.

Following satisfactory trials, the equipment drawings are passed to a commercial enterprise for large-scale manufacture. The enterprise had little experience in large-scale manufacture of multi-component science equipment and, it is now realized that a scheme that involved them in making the trial equipment might have allowed them time to build up their production unit from the understanding of the type and variety of equipment being tested. As it happened, the company received the prototype drawings sometimes with less than one year before implementation.

The basis of planning was too small, and their quality-control and production procedures had to be developed in an ad-hoc manner. The United Nations Industrial Development Organization (Unido) has assisted with the funding of a production engineer, and now their production planning is being placed on a sound engineering base.

By the end of 1978, with continued Unido assistance, the enterprise could become an efficient operation with considerable potential for large-scale production of all types of teaching aids. IPST could have helped more with the final large-scale production had it been able to recruit and retain early in its development an experienced industrial design engineer. If the initial trial equipment had been industrially designed, the need for re-design after testing would have been minimized. Distribution, repair and replacement of equipment must be well planned if implementation is to run smoothly. It is difficult to have high priority assigned to this area when management is so preoccupied with the day-to-day problems of manufacture. But again, improvement in this area will also follow from experience.

Teacher training

IPST planners realized that for successful implementation of new curricula into a school system, the new books, teachers' guides and equipment will not be enough. The teachers are the key people in the introduction of a new curriculum, their role decides its fate - they can vitalize or kill the programme. An enquiry approach to learning rarely fails because the children are not inquisitive; it is more likely that teachers have been unable to change their roles and continue with their old classroom habits that conflict with the requirements of the new curricula.

Early planning for teacher training is essential. The ultimate success of implementation depends on how well the poorest trained, most isolated teachers in the nation can be informed. As in-service instruction moves further from the people who are preparing the materials, the quality typically becomes lower. One way to guard against this is to make sure that in-service sessions are conducted by well-informed people who have been closely associated with the development of the materials. IPST dealt with this requirement for well-informed in-service instructors for their upper secondary curricula by selecting the best of the trial teachers to make up 50% of the in-service training staff; the other 50% came from the design teams. The trial teachers taught the grade XI and grade XII curricula for two years before the in-service training began. During this period they met continuously with the design teams, they were involved in revisions and in evaluation and as a result they could talk to the in-service teachers from first-hand experience in teaching and evaluating the new curricula.

The situation was different for the training of in-service instructors for grades VIII-X teachers of science and mathematics. First, the number of teachers was so great that 13 regional centres were needed. These were established within the city and rural teacher training colleges. Second, the shorter development schedule for grades VIII-X required the in-service training to begin in the year following the first trial. Thus there were no trial teachers experienced with the new curricula available to act as in-service instructors at the rural colleges. Instructors were recruited from the college staff and given three weeks' training at IPST. Usually, four instructors were trained from each college but even so, with movement of staff and awards of scholarships, the Institute had problems in keeping sufficient trained in-service staff at some colleges. By the end of 1976, however, the regional centres had given 3,000 teachers of grades VIII and IX training in the new science curricula. At IPST by the end of summer 1977, 906 grade-XI and 766 grade-XII chemistry, 937 grade-XI and 796 grade-XII biology, 1,288 grade-XI and 1,009 grade-XII physics, 713 grade-XI and 133 grade-XII physical science and 1,795 grade-XI mathematics teachers had passed through the in-service training programmes; an impressive total of more than 11,000 teachers.

The in-service courses involved the teachers in active participation by doing the student experiments, in conducting pre- and post-lab sessions, in working through self-instructional materials, in observing and commenting on model video-tape lessons, in writing test items, in lectures on evaluation and in many other activities. The courses were designed to create an interest in the IPST curricula and to stimulate the teachers to try new approaches to teaching. The teachers were encouraged to question their existing methods and to use techniques that promote student-centred activities.

In the main, the design of the in-service programmes seems to be effective. In the second year of in-service training, however, the sessions need to be carefully prepared in advance so that instructors emulate the demonstrators of new approaches to science teaching in their every statement and action. When effectively done, this does much to inculcate the new methodology. Practical evaluation exercises can also be planned to strengthen the more theoretical lectures given in the first year of in-service training.

Not much change can be expected in just three weeks of in-service training and if possible this training should be reinforced by further follow-up with the teachers during the first years of implementation of the new courses. Implementation began in 1976 when the Ministry of Education introduced the new science curricula into the grade-XI classes in the schools throughout the Kingdom. In the same year the Ministry replaced their external examination system by internal school assessment. To assist in this change-over, the schools throughout the Kingdom have been organized into 20 groups. Rather than create more committees, IPST are training members of these groups to follow up the implementation, to help teachers in their classrooms, to collect data, send it back to IPST and to call meetings of teachers in their area. If this system succeeds it could lay the foundation for continuous self-development among teachers, encouraging them to meet locally to work together to improve the teaching of mathematics and science.

Research

Considerable research continues in the evaluation of various aspects of the new curricula and the IPST teacher training programme - its effectiveness, its suitability, the nature and extent of change that it produces in the classroom, and other qualities. The evaluation team has monitored the attitudes and achievements of the trial students in comparison with their peers who have taken the old course: the trial students are on the average higher achievers and display more positive attitudes to science. A long-range research study is following the progress of the trial students through the new curricula and collecting data on their performance in university, and a full-scale nation-wide evaluation is planned after the curricula have been in use for a few years. To work on this large scale evaluation, high-calibre professional staff were chosen in 1974 to be trained in the latest evaluation and statistical methods. A special Unesco doctoral fellowship programme was arranged with universities in the United States and Australia for seven candidates. The candidates have written doctoral research proposals for their overseas universities around problems of IPST. They come back to the Institute to pre-test and administer their evaluation instruments, and to correlate the data collected. Their supervisors, who are all short-term consultants to IPST also visit the Institute in the joint role of research supervisor and adviser to one of the design teams. Also, one of the senior staff of the Institute acts as co-supervisor of the candidate. Although research findings will not be published by the overseas universities until after the completion of the degrees they are immediately available to IPST. There are other many advantages of this type of doctoral degree such as the significance and relevance of the research, and the ease of continuation of research when the candidate returns. Also, as observed by one supervisor, the complementarity that is building up in the research studies of the doctoral fellows promises to be a powerful base for future developments of curricula and teacher education throughout the Kingdom.

Even before a large-scale evaluation, however, some of the impact of the science and mathematics curriculum development is already apparent. The Universities of Thailand have joined together in a national project to improve the first year of teaching of the three basic sciences and mathematics. Also, in another national university project, changes are being planned in the preparation of science teachers through the combined efforts of the faculties of science and education of all universities preparing secondary school teachers.

"Science is Doing" exhibition—a black-box experiment

In January 1977 the IPST held a "Science is doing" exhibition to celebrate its fifth birthday. Every day for a week, thousands of students invaded the Institute to try their hand at the do-it-yourself exhibits. The physics room with its many individual experiments was always packed deep with students waiting their turn to analyse their voice on an oscilloscope or to measure the pull of gravity. Mathematics changed their maths games every other day and, when the word got around, students returned every second day to try the new games. Biology attracted hundreds of girls and boys to peer down the microscopes. Chemistry had experiments on chili extracts and many other local products. General science and the modular physical science displayed their most intriguing experiments for the children to try. Students operated the video cameras, watched the teacher training slide sets and sat through the video-tape model lessons.

Over 16,000 visitors took part in the exhibition. Loaded buses came from the provinces, some people travelling more than 500 km. Their enthusiasm for experiment and their enjoyment from doing it themselves reflected the spirited responses with which the children of Thailand are accepting the new methods of science teaching that are spreading to their classrooms.

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THE TRAINING OF SCIENCE TEACHERS IN VIEW OF CHANGING TRENDS

by John Edwards

Introduction

In this article I do not intend to 'gaze into my crystal ball' and foresee new education patterns. The article will instead present some possible ways for improving science teacher education in the Asian region, within the present system. At the same time, the reader will appreciate that generalizations are very difficult in the Asian context. When one considers that approximately the equivalent of the whole population of Singapore is born each year in Indonesia, one of the differences is dramatically revealed. A change in the primary school science curriculum in Indonesia would involve the retraining of over 400,000 teachers. It might be educative for other educators within the region to think about how they would go about such a task. This also stresses the need for extremely careful pre-planning of any changes for many countries in the Asian region.

It may be said today that there has been a general change in the attitude towards the role of the teacher. The emphasis is changing from the teacher as an encyclopaedic Mr. Know-All to the teacher as creator of desirable learning environments. One factor forcing change has been the dissatisfaction of the user-industries in many countries with the skills of the students produced by the present systems. Most Ministries of Education are calling for more humanization and relevance to contemporary life in science courses.

So, how do we produce the types of teachers who can cope with these suggested changes? The most obvious first point of attack is in getting the right people to enter the science teaching profession, people with enthusiasm and high aptitude. This introduces the salary problem which plagues much of the teaching profession in Asia. How can money be found to pay good science teachers well? Answers have yet to be found.

Experience with children

The only way teacher trainees can realistically view their suitability for the profession is through extensive contact with children. This means that there must be a major component of the training programme which allows the trainee to spend time in schools and with children in less formal situations such as youth groups, sporting groups, and music and dance groups. This can be extended to give the trainee other useful experiences with real-life problems. Such a programme is used in Indonesia where students from the secondary school teacher training institutes ("IKIPs") and universities spend three months per year in the villages. They teach in the village, and do other programmes such as functional literacy work, sanitation, nutrition and cooking. Not surprisingly, such experiences are reported to have a profound effect on the trainees.

Through repeated contacts with children, and with the guidance of experienced teachers and teacher-trainers, each trainee should be able to make a responsible informed decision about his suitability for the science teaching profession. Retired teachers could perform a very useful function here in providing guidance and advice for trainees.

At present, many schools and teachers regard practice-teaching as a nuisance. It is here that teacher trainers must be masters of public relations and organization. Trainee teachers can be of great benefit to schools and to already experienced teachers. They can introduce new ideas and enthusiasm. They can attempt new approaches usually not attempted due to lack of time, for example outdoor education experiences. Close relationships between trainees, experienced teachers and teacher trainers are mutually beneficial. All have much to learn from each other. Such ties can help to keep science teacher training programmes realistic and relevant to the current situation. They can also help to refresh and revitalize experienced teachers.

A widespread problem which must be dealt with is that of training teachers for rural teaching. Existing systems are to a very large extent urban and modern-sector oriented. One possible solution has been suggested by Bennett: "The teacher, wherever possible, should come from the community in which he is going to teach, he should already have some respect from the community members, and he need not have any high academic qualifications (which will only separate him from his community) before undergoing training. The training itself should take place in rural areas through supervised practice interspersed with short courses in the colleges. Finally all teachers need not be qualified since a significant proportion of the total teaching should be carried out by community members working on a part-time basis. For example, a progressive and successful farmer could teach practical agriculture, the local midwife hygiene and child care, and so on. Such people could be given periodic in-service training along with the full-time teachers." (1) Such an approach would greatly help to solve the teacher shortage problem and would help to make rural science courses suit the rural situation.

The activities suggested for experience with children would need to be handled with compassion and understanding. Trainees should not be given responsibility for a class until they feel ready for it. Some take to this situation readily; others need to be brought along slowly. It is here that microteaching and other simulated teaching situations can be used.

The use of microteaching

Microteaching involves teaching a short lesson to a small group of peers or children. This lesson is then usually reviewed either on video- or audio-tape, or from classroom analysis forms filled in by observers. After careful analysis and rethinking, the teacher can then re-teach. This process can be repeated until learning has been accomplished.

Perlberg recommends microteaching as one of the few techniques from developed countries suitable for rapid improvement of education in developing countries.(2) Techniques for microteaching have been reviewed by this writer.(3) Its great advantage is that microteaching allows the trainees to make mistakes and learn from them, in a relatively low-pressure situation. Such opportunities are essential for the development of the trainees, particularly if they are being introduced to completely new approaches to science teaching.

Having schools attached to teacher training institutions is a great advantage. These schools can act as a 'halfway-house' between simulated situations and the real thing. The Development School Programme in Indonesia is an encouraging and successful step in this direction. It is also found that these schools will provide useful inputs back to the curriculum developers for curriculum renewal purposes.

Major aspects of a training programme for science teachers

There are five other major aspects on which the training of science teachers might be concentrated:

1. Getting to understand oneself, and to understand children and how they think;
2. Being trained in research techniques and curriculum development techniques;
3. Developing familiarity with the science curriculum materials available, and learning how to select materials suitable for each situation;
4. Achieving mastery of the science to be taught and of alternative teaching techniques;
5. Being trained in evaluation techniques.

Understanding oneself and the child

In the new more open teaching styles towards which many countries are moving, teachers must understand themselves and how they affect other people. A great help in this area is the use of sensitivity training and inter-personal communication techniques. At the SEAMEO Regional Centre for Education in Science and Mathematics (RECSAM), an inter-personal communication programme has been used successfully with key science personnel from South East Asia.(4)

Probably the most important part of the training programme for science teachers involves giving them insights into how children think. Contrary to popular views, Asian junior science programmes can be said to reach a high academic standard. Indeed, the content of many programmes is much more difficult than that to be found in the programmes of countries such as the United States of America, the United Kingdom, France and Australia. Unfortunately, many concepts are introduced at inappropriate stages: some advanced concepts such as displacement volume are introduced early, while other simpler concepts are found later in the programmes. For this reason I think it very important that trainee science teachers be introduced to the techniques and findings of Jean Piaget.(5)

Almost any concept can be understood at different levels. Take the example of respiration. Children of six can think of respiration: breathing in and breathing out, as if the body is acting like a pair of bellows. When they reach ten or eleven, children can look on respiration in a different sense, but it is still intuitive. They know that the motor car burns petrol, and by simple analogy can appreciate that the body burns the gas called oxygen. But it will require formal thinking before they can understand the various exchanges that go on, and the various changes that occur in the blood.

In science teaching, and curriculum development, we must ask ourselves, "In what sense do we want the child to understand this topic or concept?" For the science teacher, this requires experience in listening carefully to what children say and watching their method of working and discussing, together with the arguments they use. If teachers have been trained in Piagetian theory, and have had experience using the clinical method of interviewing children, they should be able to assess the level at which the child is operating. This allows teachers to choose the most appropriate materials and methods for each child.

The curriculum developer can use Piagetian theory in two main ways to help the teachers. The best way would be to produce a multi-level curriculum, with each topic being treated at a number of different levels. The teachers could be trained in ways of fitting particular children to particular programmes. The other approach is to use an option system, where the children have a range of activities from which to choose. Again, the teachers may direct the children to the most suitable activities. This is the approach that was used successfully by the Australian Science Education Project (ASEP).(6)

It is important that teachers and curriculum developers be made aware of the problems that come from introducing concepts too early. If you introduce an experience that is "too advanced" for the intellectual level of the children, they may ignore it. But, on the other hand, they may distort it, and then assimilate the distorted concept. We then have the problem in later teaching where children have false preconceptions which block proper learning.

In understanding discussion-group problems, child development theory is again a help. Often in secondary schools the situation arises of a discussion involving a mixture of 'concrete thinkers' and 'formal thinkers'. In such a situation, the formal thinkers will have problems seeing the difficulties of the concrete thinkers. And the concrete thinkers will have problems following the arguments of the formal thinkers. Teachers need to be sensitive to problems such as these which can arise in group work or discussions. Similarly, the teacher needs to appreciate that sometimes, even despite a brilliant and clear explanation, some of the children will not be able to understand. They are just not ready - and this is nobody's fault. In this respect, research projects such as RECSAM's project on the development of science and mathematics concepts in South East Asian children will be invaluable resources for the region.

The role of research

The OECD* Education Committee, when commenting on in-service education in 1972, stated: "Present national policies give an impression of rather unco-ordinated, haphazard activities, except perhaps in Sweden where priority on in-service courses has been given to teacher trainers and teachers engaged in research and development activities. If teaching is to be a rewarding occupation the present detachment of teachers from the excitement of involvement in research and development programmes must be overcome."(7)

Husen has said that a major influence in Sweden is the emphasis on training in research and participation in research during pre-service training. The basic philosophy is that people who have helped to discover facts find it easier to abandon erroneous and biased notions and practices - in short, to change their attitudes. Also, when in-service courses are held the teachers come in as contributing equals, not as 'inferiors' to be lectured to.(8)

In this respect, the programme set up by Dr. Ruth Wong for pre-service teacher training at the Institute of Education in Singapore is a good model. The trainees have a very demanding programme, including four research projects. Some of these projects are exciting pieces of work. As a result, a solid core of research on Singapore schools is being built up - an invaluable resource. Headmasters and experienced teachers have expressed great satisfaction with respect to the products of this programme. Through follow-up of these projects the teachers should be tied-in to a continuing education programme.

Continuing education

Continuing education for teachers seems to be a universally accepted concept. For it to be successful there must be support systems available. Science Teachers Associations are very useful in this context. The growth of such associations in Asia is an encouraging trend. Teacher Centres have also proved successful in many countries.(3) The Malaysian system of having Centres of Excellence established throughout the country in association with well-trained key personnel is a very successful innovation. The mobile units used in Indonesia (and in Tanzania in Africa) also provide a promising avenue for continuing education, particularly in Indonesia where radio is to be used to extend the work of the units.

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* OECD: Organization for Economic Co-operation and Development (of Europe)

In some respects curriculum development work plays a similar role. An early report on Malaysia's primary maths/science project, Projek Khas, stated: "If teachers can be invited to be involved in the project right from the start and continue throughout the period of development, they are more likely to view the project as a means of solving their own problems, and their commitment at all levels is assured." Members of the science writing teams in Indonesia, and writers for the Lower Secondary Science Project in Singapore, work part-time or in their spare time on producing materials. Despite the fact that they work under tremendous constraints, such experiences are professionally very valuable, as is the experience of trying new curriculum materials.

The role of curriculum development

Training in curriculum development techniques has become very important in many countries with the shift in emphasis towards the teacher as an autonomous curriculum decision-maker and curriculum producer. This move is not surprising following the extended period of operation with project materials having voluminous prescriptive teachers' guides. Romey's idea of the "curriculum-proof" teacher (9) appears to be taking hold. Throughout South East Asia there are many talented people producing their own materials. This writer remembers with great delight a first sight of the excitingly creative science modules produced by two teachers at the Philippine Science High School. Sadly, however, exciting developments such as these seldom get much publicity. This seems a good point to press for the keeping of a register of active science education people in each country, so that they can be called upon when necessary. A necessary companion piece to the register is a continuing inventory of projects—and materials—in science education. The national lists could then be collated and disseminated by Unesco and sub-regional institutes.

Anyone searching for a good Asian model for curriculum development and implementation need go no further than the Institute for the Promotion of Teaching Science and Technology (IPST) in Bangkok. Their procedure is very thorough and they have produced materials of quality. Indeed, the countries who have produced their own materials seem to be more satisfied than those who have adopted foreign programmes with little adaptation. This stresses the wisdom of the advice offered by a working group of South East Asian educators at the RECSAM Seminar on Strategies for Curriculum Development in South East Asia in March 1972:

"A country should never adopt, sometimes adapt and always invent programmes."

The role of so-called "teacher-proof" materials in America and Australia has been important. They have fulfilled an important teacher education role. The fact that teachers are now rejecting them should be taken as a measure of their success. For this reason, the preparation of very detailed teacher guides for Asian science curricula is recommended. This does not mean that every teacher has to follow the guide. Imaginative teachers will always adapt any prescribed programme and will often design their own parallel programme. But through such a guide the teacher who needs help can get it. This is a very effective way of building up the subject-matter knowledge and pedagogical competence of the science teachers in a country.

Choosing from the materials available

It is also important for teachers to have means available to help them choose between available materials. Background in Piagetian theory is one such technique.(10) Another is the ability to test the readability levels of the materials. The cloze procedure* is a simple, valid and sophisticated technique for measuring readability.(11) Much research, however needs to be done in this area with Asian languages. Teachers need to be aware of a range of curriculum analysis techniques. Along with those already mentioned, content analysis (12) and 'puissance analysis' (13) are other possible techniques helpful for the would-be curriculum decision maker.

Content and pedagogy

Some readers may be surprised at the lack of emphasis here on science content and pedagogical techniques. These should be part of the training process, but they should be secondary in importance. In pre-service training the emphasis should be on teaching the trainee the basic concepts on which he can build his own further study. This study can be aided by self-instructional materials for teachers and by good quality curriculum materials, in conjunction with the continuing education techniques discussed earlier.

Through the extensive practice-teaching programme suggested earlier, the trainee should have a chance to try out many different pedagogical techniques so that he can find the ones that best suit him. With the growing emphasis on activity-centred methods, emphasis should be on developing confidence in the laboratory, mastery of laboratory management techniques, the introduction of relevance to the ecology into the science programme and skill in small-scale techniques. Since most countries at present have overcrowded science syllabuses, it would also be useful to spend time on techniques for coping with this - hopefully temporary - situation.

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* This technique uses reading selections from which words have been deleted; the blanks are then to be filled in.

An understanding of evaluation

The last area to be taken up is the one which is perhaps the least understood of any basic area by science teachers. Few teachers really understand the real function of evaluation, how to go about evaluating in a meaningful way, and how to report effectively. The major weakness is that of narrowness. Too often, evaluation is seen only as paper-and-pencil tests. Reliability and validity are seldom considered. And the "statements of fact" that are made about students' abilities and achievements go far beyond what is honest from a consideration of the statistics.

Teachers need to be introduced to a broader view of evaluation and to an understanding of the true meaning of test scores. Such important areas as confidence-levels should be clearly understood by teachers. Any teachers who have the reverence for the individual child, which can be seen as the stamp of the true teacher, would shudder with shame if they were made aware of the massive hoax which educational "evaluators" have perpetrated for years on unsuspecting parents and students, and often on themselves.

A major component of pre-service programmes should be directed towards developing a healthy disrespect for test scores as they exist in present systems. To build a more accurate and honest evaluation system will take a long time, but it is a task essential for science educators.

Given components such as those mentioned, beginning with enthusiastic teacher trainees, increases in teachers' salaries, and administrators dedicated to creating conditions where the teachers have the time necessary to function effectively, the chances of improving science education in Asia appear to be very high.

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PRODUCING LOW-COST SCIENCE EQUIPMENT FOR DEVELOPING COUNTRIES -

a report of a commercial project in Hong Kong

by Raymond F. Simpson

The problem posed

For many years devoted science teachers have been constructing simple apparatus from pins and string and sealing wax, bottle tops and tins. No doubt they have learnt a lot of science and developed their practical skills but the overall effect has been limited.

Anyone who has worked through the Unesco "Sourcebook for Science Teaching" will know that it is no easy matter to get simple apparatus to 'work' - indeed it often needs a very good scientist to appreciate just how to modify the design if the right-sized bottle is not available locally. Practical work involves a great deal of effort which has little influence on examination results, so it is not surprising that it is neglected by all but a few enthusiasts. We may pay our respects to 'discovery learning' and design 'open-ended' questions to encourage it, but in so many schools 'chalk and talk' still prevails, theory precedes practice, and practice, when conducted at all, is a cookery-book exercise.

If results do not agree with theory, teachers feel that they lose face and blame the apparatus, which is then discarded and lies dusty and hidden in a bottom drawer.

If science is to contribute to development then it is by solving practical problems rather than by hiding them. Without practice, school science becomes an intellectual exercise which, for the majority, makes little impact on their daily lives. But how can practical experiences be brought within reach of every child? Clearly we need an abundant supply of apparatus cheap enough for all schools to afford. In Hong Kong, with nearly half the work force engaged in almost every conceivable type of manufacturing industries, there ought to be no problem. Yet there must be for otherwise enterprising Hong Kong businessmen would have moved into the market long ago.

The main problems are the small annual demand, the large capital outlay, the storage and distribution - the very problems in fact that lead to high prices elsewhere. How these might be overcome has been occupying the mind of this writer for many years but it seemed to require an immense undertaking that one individual could never hope to afford and one with so large a risk for so little profit that no industrialist was interested. The production of books and ball-points, pencils and protractors, or even taps and test-tubes, were reasonable risks but to stock the one thousand-and-one items listed in the standard science catalogues seemed a sure way to bankruptcy.

Hong Kong provides a stimulating climate for such ideas, nevertheless, and over the past twenty years, it has been possible to identify many items already produced locally which could be used for simple physics apparatus with only a minimum of modification . . . "Perhaps a plastic battery box would make a suitable kit container and a toy car could be a dynamics trolley if only more suitable wheels could be found" . . . "Would the mechanism of a walky-talky doll provide the component needed?" With such thoughts in mind this writer initiated a simplified apparatus project some ten years ago.

The 'Simplex' project

The project remained a 'one-off' operation until about two years ago when a loan of US $2,000 was received from an educator who was interested in providing kits for his school pupils to use at home. It was at this moment that 'Simplex' was born - Simple experiments - complex things made simple, or just Simpson's experiments perhaps. This became an absorbing hobby in the evenings and holidays, requiring the setting up of a small home-workshop and visits to local factories. Without the loan and the feeling of obligation implied it would have been tempting to give up long ago but now, after innumerable frustrations, the successful completion of an initial series of 12 self-instructional kits which are already in small-scale production can be reported.

The essential basis for planning was that any item developed should be capable of commercial production at prices that would be economically competitive - there would be little value in making copies of traditional equipment if the cost were almost as high. In practice, the financial constraints and lack of technical help that at times seemed so discouraging, did much to ensure that the kits could really be produced for sale in the US$2-to-$5 price range. At this price, individual or small group experimentation becomes possible in developing countries, whereas with kits costing US$20-to-$50 it might have meant that only one set could be purchased and presumably reserved for teacher demonstrations only.

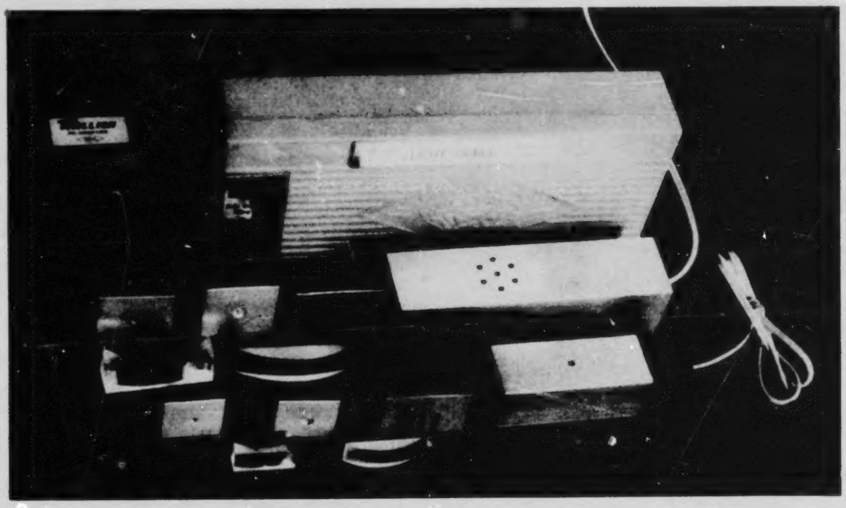
It was decided that the initial series should cover the essential practical work for a physics course in 'Light' up to the English General Certificate of Education "O" level. By omitting certain experiments, however, the kits should be equally suitable for examinations comparable to the English C.S.E. In fact, the basic principles of physics apply universally, and teachers should find no difficulty in extracting useful practical experiences from the kits in whatever country they are working. Professionally acceptable standards of both appearance and operation have been insisted upon, as the kits are intended for serious study. The fancy gimmicks and packaging found in many educational toys have been avoided but the kits are still sufficiently attractive to encourage study at home.

A brief description of each of these kits may help readers to appreciate the special nature of the designs and the way in which they incorporate parts produced for a wider market.

The Simplex 'Light' series—aspects of technical significance

The 6V 'Student' light-source kit. As with the other kits, the materials are housed in a strong and attractive battery box which was already in local production. The source itself is of extruded aluminium with a fine matt-surface finish. The size of tube had to be carefully chosen to match the bulb holder, a tight fit being obtained with a ring of plastic water pipe. The bulb type is commonly available and its wattage chosen to ensure long battery life or, alternatively, permit operation from a small transformer. A 'major' (12V, 18W) version of the light source is also available for schools with main electrical supplies.

Mirror kit. Spring paper clips support the plane mirrors while a thin stainless steel strip provides either a convex or concave reflecting surface which is variable in curvature. (Steel is preferable to aluminium, and not fragile like glass). The parabolic reflector in the kit is a product of the electric torch industry.



The Simplex 'Student' and 'Major' Light Sources with accessories, Kit box and transformer

Light Sources and samples of items included in the Simplex Light Kits

Lens kit. Spherical glass lenses with only slight imperfections were obtained at discount from a manufacturer of film projectors. One element of the compound lens was selected and the experiments designed around it. The acrylic plastic cylindrical lenses were cut in bulk and partially shaped by machine while the small Fresnel lenses were found as part of an advertising display.

Prism kit. High quality acrylic plastic prisms, including a semicircular one, were cut from a sheet of the required thickness to minimize polishing. Nylon line, used for fishing, illustrates total internal reflection and introduces fibre optics.

Colour kit. A commercially-produced miniature fan operating from a pen-light battery was adapted to rotate a disc to which coloured plastic sectors can adhere. Polystyrene beads produce a rainbow, while dressmaker's sequins illustrate complementary colours.

Telescope/Microscope kit. Lenses from a simple telescope, held in spring clips, form images that are located on a screen made from a translucent visiting card. A miniature microscope/telescope combination, already in regular local production, is included to provide a highly magnified image of good quality.

Camera kit. The shutter and adjustable lens from a cheap camera illustrate their operation. The pin-hole camera is made from moulded tubes taken from a toy. Examples of still and cine-colour films are included.

Kaleidoscope/Periscope kit. Toy versions were obtained unassembled so that children can understand the operation more easily and construct their own.

Eye and Spectacles kit. This kit has a number of novel features including a model eye and a real spectacle lens. Astigmatism, persistence of vision and colour blindness are also demonstrated.

Interference and Diffraction kit. This includes accurately ground plates from the optics industry and a plastic diffraction grating made by photographing the 'shading' film used by draftsmen.

Polarization kit. The sheets of polaroid are used in sun glasses and aircraft anti-glare dials. Specially chosen plastic materials show fascinating stress patterns. A film container and camera lens holder combine to make the simple polariscope.

The Battery box. A standard battery box has proved an ideal container which, with internal connections and a jack socket as used in transistor radios, enables easy connection to the light source. The box also serves as a container for spare parts.

Checking the kit contents. A diagram of the contents of each kit is included in the lid to assist students and teachers to check in case any attractive items happen to be 'lost'.

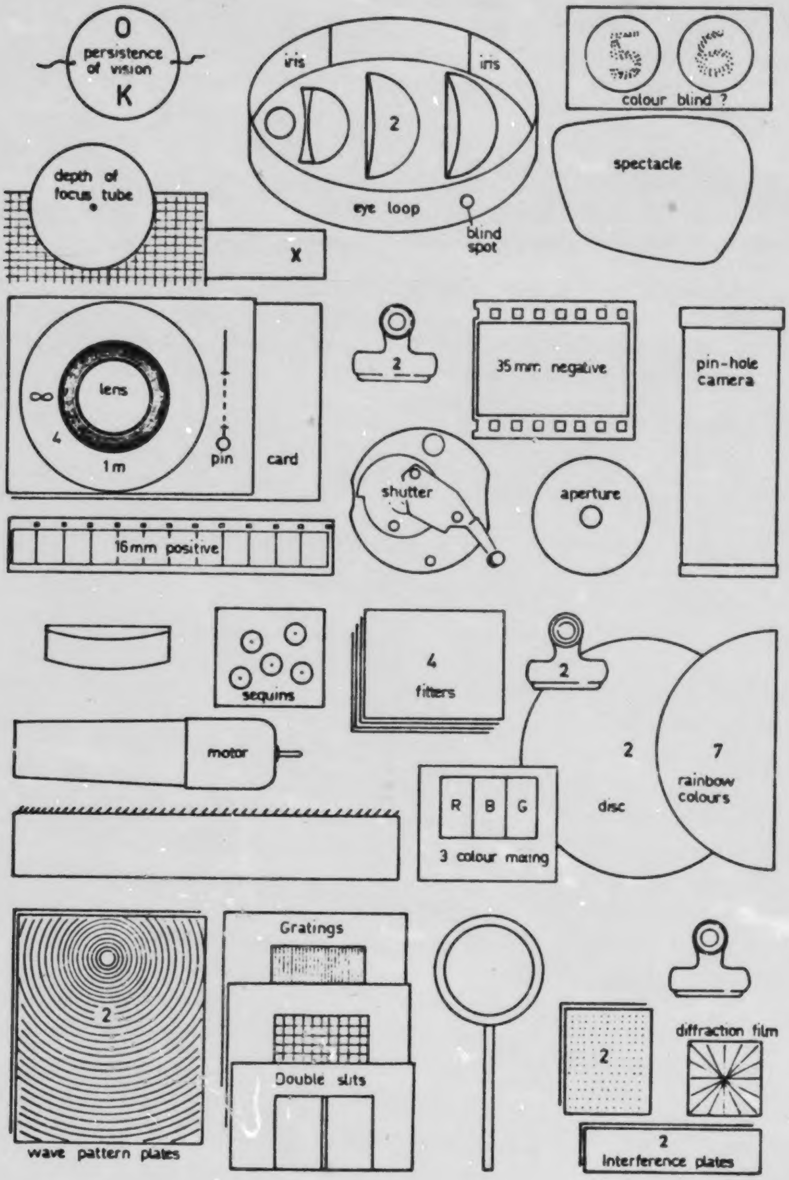
Problems encountered in the Simplex project

It may be helpful for others wishing to follow a similar path to consider the design and production problems that may be encountered. In the Simplex project these proved far greater than may be apparent from the basic nature of the final products for reasons which may be itemized.

1. There was the difficulty in locating the small factories likely to be producing suitable items and then winning their approval to look around - they sometimes thought we were engaged in industrial espionage and were attempting to undercut their business.

2. It is not easy to explain to factories that you do not want their products for their original purpose. You may see a plastic moulding for a lamp stand and say to yourself, "I wonder whether that would do for my telescope?" while the manufacturer still wants to sell you the complete lamp.

3. Even when you do manage to obtain samples, the parts acquired from different sources are not always compatible: the tube sizes match but the screw threads differ - or vice versa.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Gratings
Double slits
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wave pattern plates
2
diffraction film
2
Interference plates

Sample content layouts inside the lid of the Simplex Light Kits intended as a check list for teachers

4. The need to ensure a future supply means restricting or changing the design to use only those items that you are sure will not go off the market. Small factories change products after an order is completed, so alternative sources must be kept constantly in mind.

5. The relatively small number of items required does not attract manufacturers to start production. For instance, to make moulds for cylindrical lenses would not be economic for orders of less than about 20,000 and this would have swallowed up the entire capital available while producing only one or two of the hundred-plus parts required for the kits.

6. A problem of quality control always arises when relatively unskilled labour is used. This is considerable when items are hand-made but with stampings, extrusions and mouldings made by machine one can be reasonably sure that the basic parts are accurate and only the minor modifications have to be checked.

7. There is the difficulty that arises from the multiplicity of suppliers. For the 12 kits that make up the Simplex 'Light' series there are at least 50 different suppliers of small items. Fortunately the compact area of Hong Kong reduces the problems of control and collection. Indeed, Hong Kong could be the only place in the world where this type and level of production could be done without enormous effort and expense.

8. While it is theoretically possible to set up a composite factory which would make most if not all of the items, an output of about 100,000 kits would probably be the minimum order to make it economically viable. Without full government backing this is unlikely and even then the authorities would really prefer 1,000 copies of 100 different items to cover the full course and allow for school trials and subsequent modifications.

9. Because of the uncertainty of even medium-sized orders the Simplex kits were designed so that they could be used by individual students for home study as well as in the school laboratory. In this way the market is potentially greater and a possible clash with items already adopted in schools would be less crucial.

10. The concept of home study had a considerable influence on the kit design. It necessitated a cheap and light-weight, compact but sturdy, fully self-contained package with instructional notes of sufficient interest to hold student attention but adequately linked with school work to justify parental purchase.

11. Certain experiments could not possibly be included in a kit packed in a standard container measuring 8" x 3" x $1\frac{1}{4}$" (about 20 x 8 x 4 cm). The amount of experimental work at present performed in many schools is very limited, however, so a few omissions were considered of little consequence.

12. In developing countries, especially rural areas, even minor items like clips and coloured acetate sheet cannot easily be found and so everything must be provided in the experiment kit.

13. Repair and maintenance of sophisticated equipment is very difficult, especially in outlying areas, even when technical assistance is available. Simples kits have therefore been kept extremely simple in design and, because they cost only a fraction of traditional equipment, multiple purchases are possible and repair is not so vital.

14. Open storage trays gather dust and equipment quickly deteriorates in the humid conditions so often prevalent. So a kit box was chosen that can be easily sealed with cellophane tape. Moreover the small uniform size facilitates bulk storage and distribution to rural areas.

15. International transportation costs have risen with oil prices and packing has become increasingly expensive. The use of plastic and aluminium components and the miniturization necessary for the compact boxing has reduced the weight of the kits and enabled the postal/packing charge to be kept down to about 10% of the cost of the kit. It would have been ridiculous for a piece of equipment to have been made at low cost for developing countries only to find the charge for sending it almost as great.

16. It might be thought that a larger output will lead to considerable economies of scale. This is no doubt true when a new product is being developed but is less significant when the kits are based on items that are already being produced in large numbers for other purposes. Another point to consider is that overheads rise when moving from a family-style packing and assembly activity into one that requires special premises and full-time staffing at all levels.

17. Placing a large order means that a considerable amount of money is tied up in stock which, in the case of school equipment, is slow moving and may deteriorate or become out-of-fashion with curriculum changes. These considerations may more than outweigh the lower unit cost of mass-production. This is overcome in the Simplex approach which enables moderate quantities of items to be acquired at short notice to match the level of orders received. Kit production is then largely a matter of assembly.

18. Not until all the components have been collected can assembly commence, so the need for assembly workers tends to be intermittant. A production level of a few thousand kits a year could probably be handled as a holiday job for senior students, but very larger orders would necessitate permanent staffing with the risk of periods of inactivity and consequent inefficiency.

19. The distribution of kits is a major headache. If large international companies provide this service then they have their own operational costs which substantially increases the selling price of the kits and defeats the purpose of the project which is to produce equipment that developing countries can afford.

Thus, although world-wide distribution could potentially increase sales, the consequent price increase might curtail demand with no ultimate benefit either to the producer or the Third World. Nevertheless, an efficient sales mechanism is essential to ensure a financial return that will provide the capital to develop further kits (a second series is now being developed).

Direct contact with Ministries and schools would be advantageous but there are conflicting commercial interests that may make it essential to work through local agents even though they will want their own "cut" and push up prices once again.

Policy implications for equipment production and distribution

Production of science equipment through technical schools, with a few notable exceptions, is low in quality and, if in any quantity, conflicts with the students' legitimate educational aspirations. Furthermore, the items produced are only cheap because of the free labour of the students. Alternatively, the involvement of university engineering departments has usually resulted in designs of quality but with high production costs. Science teacher training institutions ensure adherence to educational requirements but the items constructed have remained 'home-made' in appearance while teachers' holiday courses, although providing good practical training, are perhaps better confined to assembly and repair than basic production. Specially designed workshops are potentially the most effective way to produce school equipment but the output has usually been far less than was anticipated.

Problems associated with government workshop production

1. Production costs. A fundamental problem of governmental and international organizations is that production does not have to be economically viable. Accounts rarely include Government salaries for technical staff, seconded teachers or specialists offered through international aid. The workshops themselves are usually built at Government expense on Government land for which no rent is demanded while much of the heavy equipment is supplied free from overseas. It would be comparatively simple, and most revealing, to work out the true cost of the items based on the production of a few thousand at the end of a five-year programme. It would probably be very close to that of the imported equivalent.

2. Industrial efficiency. If commercial firms are responsible for the development they have to be efficient to avoid bankruptcy - they would be forced to dismiss idle staff and modify designs to keep the cost down. It would be an eye-opener for many to see a Hong Kong factory where, in good conditions, a thousand women produce 200,000 small motors a day at a cost of little more than U.S. 10 cents each - and the women are still paid at rates second in value only to Japan in Asia.

In the science equipment field a steady output of about 100 a day of any item would soon saturate the market so that full economies of scale are not easily achieved. Nevertheless, it is still possible to design science equipment so as to take advantage of mass-production processes. To achieve this will require a change of strategy - we must build our courses round the items readily available rather than construct our curricula in theory, only to find that we cannot afford to provide the equipment to put it into practice.

3. Labour-intensive versus capital-intensive approach. It can be argued that in developing countries there is a vast labour force lying idle that could be employed very cheaply and that a labour-intensive approach is to be preferred. This seems irrefutable at first sight but in reality a selective use of materials from more capital-intensive industries is more economical. Even the least developed countries make fine pottery but for them to produce 'Polaroid' at this stage would be pointless. To use skilled craftsmen to make multiple copies of apparatus is usually uneconomic: it would be far better if they spent their time thinking of ways to avoid doing this. They should certainly concentrate on prototype development, but mainly by locating parts already being mass-produced. With the increased use of mass-produced components the unskilled labour-intensive input could be employed for assembly, packing and distribution rather than for routine jobs concerned with basic construction.

To locate suitable components, a team of designer and craftsman should visit factories in each major city to obtain samples of every small item produced. This will probably require Ministry backing as industrialists guard their designs very carefully.

4. Product finish. One of the great advantages of employing industrially produced parts is the superior finish that is possible. Plastic may be more expensive than wood but the fine surface and colours available may fully justify the cost (although plastic is often highly breakable). Hand-painted wooden items usually look shoddy by comparison. There is of course a danger that a fine finish may hide the underlying educational principles and care must be taken to see that items selected are of the simplest possible design and can be taken apart for detailed study. A further consideration is durability. For example, in humid conditions, the choice of aluminium despite its higher cost is preferable to steel with its tendency to rust.

5. Sophistication of workshop equipment. It is unrealistic to expect a workshop designed for school equipment production to compare with that found in major industries. If we want high-pressure plastic pressings once a month we should go to a company that specializes in such things and not seek to duplicate expensive equipment. There are dozens of similar processes which would be more economical in the hands of commercial companies, ranging from spring making to die casting. It is wise to

consider every piece of expensive equipment before purchase and assure ourselves of its cost-effectiveness for, although it may be convenient to have our own moulding and milling machines, this can have the disadvantage of encouraging an inappropriate style of production.

6. Effective utilization - an alternative approach. Assuming that elaborate equipment is already available, it is possible to ensure its full utilization by taking on commercial production or developing complementary production activities such as making educational toys. However, for utmost efficiency, the most dramatic results might be achieved by appointing a factory manager with very considerable freedom, a high salary, an agreed budget and a contract that made it clear that he would be dismissed if after, say, two years the whole project was not able to stand on its own feet financially. In other words, a Government-sponsored workshop run on a commercial basis.

7. International visits and aid. It would be most beneficial if a team consisting of an equipment designer and a craftsman could be given the opportunity to travel to other countries where industries flourish and allowed to buy samples of essential items that cannot be produced locally, with a view to possible bulk importation later for use in local equipment production.

The availability of foreign exchange is of course vital but it need not be excessive because only certain missing parts need be purchased. It might be the bulb holder of a table lamp, a transistor radio ear plug, the plastic pressing used in a certain toy, or a special type of toy electric motor. Instead of bringing in expensive finished products, international aid would often be better spent providing the missing parts and leaving the bulk of the production and assembly to be done locally.

8. Science as an agent for development. A widespread introduction of science is frequently advocated on the assumption that it contributes to development. This is very questionable when taught by rote or formal methods especially when practical work is minimal. A greater impact is to be expected when the experiments are linked with pupils' everyday experiences. For example, science students could learn to make efficient use of resources by finding the relative cost of cooking by charcoal, kerosene and bottled gas. Whenever possible, apparatus should be designed to encourage a guided-discovery investigation in which the student has to evaluate the efficiency of alternative techniques rather than to assume that the more expensive 'fool-proof' apparatus must always be the best. It is the process of personal investigation and decision making that is likely to contribute to development rather than scientific knowledge that remains unapplied. The Simplex kits have been assembled for discovery learning.

Note: "Simplex" (G.P.O. Box 3867 Hong Kong) is now the registered trade mark of an independent company that has taken on the responsibility for production and distribution of the kits described here.

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SCIENTIFIC LITERACY FOR ADULT LEARNERS

by H.S. Bhola

Philosophers have invested considerable effort in understanding the nature of human knowledge. They have explained to us the special nature of facts, and how these might differ from opinions. They have tried to help us distinguish between unexamined beliefs and universal values. They have also defined science, and what it means to be scientific.

What is science?

Science, philosophers tell us, is any department of systematized knowledge when such knowledge has been obtained by using a method of discovery. This is a method of generating knowledge involving actual observation, hypothesizing, organized experimentation to test hypotheses, and ordered thinking. It is called the scientific method. Systematization requires that facts, reasonings, beliefs and doctrines concerning the subject be arranged logically.

What is scientific literacy?

In this paper, when we talk of scientific literacy, we are really referring to literacy in the natural sciences. In other words, we will be talking of teaching adult learners those basic ideas that form the core of the basic sciences of chemistry, biology and physics.

As adult educators, we seem to have done somewhat better in teaching adults literacy in the 'social' sciences than we have in teaching literacy in the natural sciences. At least we have had the right aspirations. We have talked of teaching self-awareness, and conscientization to adult learners in our literacy and adult education groups. We have suggested that instead of only teaching them to read the word, we teach them to read the world. We have sought to teach our adult learners to be sociologists of their own situation and political scientists of their own plight.

In the teaching of literacy in the natural sciences, we have not done as well. It must be said that as we talk of scientific literacy here we do not have unreasonable aspirations. We ought to give adult learners the core of scientific ideas that they could use to cope with life around them: to come to terms with their bodies; to understand the land they till and the animals they depend upon; to learn to harness energy to make their work less brutalizing; and to live in harmony with their environment. Margaret

Mead has suggested that practically any idea could be communicated to a bright four-year-old, in some form. There is no reason why the core of scientific ideas from the natural sciences could not be communicated to semi-literate and newly literate adult men and women around the world.

Scientific illiteracy, a real problem

We live in a technological age. Technology, however simple, surrounds us in our homes whether we light them with electricity or candles. Technology surrounds us at work whether we work in a factory or in the field. Farmers even in the developing world are using hybrid seeds, chemical fertilizers, and tube-wells. Many of those farmers are riding bicycles and using penicillin powder. They listen to the radio, travel by train, and sometimes go to the movies.

While technology surrounds us, however, our scientific illiteracy is abysmal. The examples of our ignorance are less amusing and terribly tragic. There is the story of an Indian woman for whom medicine was supposed to do good, irrespective of the condition it was supposed to cure. She gave her husband a laxative when he was already suffering from diarrhea. Since he now had the medicine, he was expected to feel better - except that this medicine had been brought home for somebody else, at some other time, for a very different problem - constipation. I have personally come across a college student in a provincial town in Asia who swallowed in nosebleed in the hope of conserving blood. He was sure the blood would somehow go back to where it belonged. I have heard of cowdung being put on deep wounds in the hope that the holy manure would cure, and I have seen a grandmother put her little grandson's urine in the little grandson's ear to cure an ear infection. One can easily collect horror stories of damage done to crops and clothes and food and farms for lack of scientific literacy.

The costs of scientific illiteracy in terms of life and pain are incalculable. Something surely needs to be done. The problem is both real and live.

Teaching of scientific literacy: a stocktaking

What is our record as adult educators in the teaching of scientific literacy to adult learners? It is certainly not very good. We have, of course, been conducting for some time programmes that teach the prevention of tuberculosis, malaria, cholera, and other water-borne diseases. We have given lessons to millions of men and women, in thousands and thousands of villages, on home economics and family planning. And we have, of course, been teaching improved agriculture as part of adult education, agricultural extension and community development programmes for as long as one could remember.

The teaching of this science-related knowledge does not qualify, however, as the teaching of scientific literacy in the full sense of the term and intent. For example, we have made no attempt to explain why we are proposing particular health practices, or particular approaches to the planting of crops, or the use of particular insecticides in the fields. Such teaching has not only been superficial, it has been atomistic. We have not taught science. We have not taught the basic propositions of biology, chemistry and physics, or the logical structures that organize facts and ideas in these sciences. What is an even more serious omission, we have not taught the scientific method. Thus it was impossible for adults to make any generative use of those inert science-related facts that may have been taught. As a result, things have to be taught afresh every time in every new situation. There is no connection established between what has been taught before and what has followed later. The adult learners are given no general ideas to transfer what they learn about their own health to the health of their animals. And they cannot transfer what they have learned about human nutrition to the need for nutrients in the farm.

A somewhat more organized attempt at the teaching of scientific literacy was tried in India by the introduction of Vigyan Mandirs - the shrines to science. The idea was to establish many Vigyan Mandirs in rural areas, where the farmers could come to look at specimens and exhibits, to use instructional materials, view films, and even conduct simple experiments. This project was introduced with great enthusiasm some 20 years ago, but is now heard of no more. There is no mention of the scheme in recent reports of the government of India. There is no other remnant to be seen, either, of Nehru's dream of universal mass scientific literacy for India. The only other world leader who seems to have dreamed of scientific literacy for the masses was Mao. It is difficult to say yet how far Mao's dream may have been realized.

More recently, an attempt at teaching science which has had some luck is the Ethiopian Nutrition Institute. The Institute has conducted a rather thorough and systematic programme of dissemination of scientific knowledge. Although the focus is somewhat narrow, in that it is about human nutrition only, they have backed their dissemination with their own research and development; and they have tried to provide their learners with the structure of ideas which undergirds instruction in nutrition. That is, they have not merely given nutrition-related instructions, they have tried to teach nutrition as a science. It is not easy to find many such examples of teaching scientific literacy to adult learners in the Third World.

Why are we not doing better?

The answer to this question is complex. One explanation for why we have paid such little attention to the teaching of scientific literacy to adult learners might be that we have neglected scientific literacy in general. Our cultures are already technological, but we remain scientifically illiterate - not just newly literate adult learners, but 'educated' people as well. In the Third World, the schools have generally done a terrible job of teaching science. They have taught their pupils some disconnected scientific facts which the students have been quick to forget. Schools have taught their students meaningless formulas and had them watch experiments which neither the students nor their teachers were able to relate to the problems of life surrounding them.

In adult education, we have hardly done anything at all with the teaching of science. The result is that most of us have established magical relationships with the technology that surrounds us. We know that technology somehow works. We know that there are some switches and some plugs to throw, and there are some levers to push and pull that make magical machines work. A toaster will give us toast, an iron will press our shirt, a radio receiver will blare out music, a tractor will start moving, but we seldom know why. Thus many of us never see through the mystical power of the machine and of those who make them. We remain scientifically illiterate and subject to social manipulation. This connection between the scientific and the social is one of the most significant - and potentially dangerous - facts of today's world.

An interesting reason why we have not done better in terms of teaching scientific literacy to adult learners might be that adult educators themselves are scientifically illiterate. It doesn't take long to realize that most of those who are working in adult education in Asia, Africa and Latin America today have come from the helping professions. Many of them have come from social work and others from education and the church. Their knowledge of science has been next to nothing. In fact, many of them have been able to get through their high school without ever knowing much about physics or chemistry or biology. Yet the scientific literacy of adult learners will have to begin with the scientific literacy of adult educators.

During 1966-68, the writer was in charge of the mass communication and publication programme of Literacy House, Lucknow, India. Literacy House has played an important role in the production and promotion of reading materials for new literates, but not much has been done there in the area of scientific literacy. When it was suggested to the three editor-writers on the Literacy House payroll that we start writing books to teach scientific literacy, they were somewhat taken aback. Different reasons for not doing so were advanced: the material would be academic, difficult to understand, unrelated to the needs and interests of adult learners, and so forth. The problem was not that they weren't convinced of the need to teach scientific literacy but that they were unable to write on scientific subjects. It was quite easy for them to retell folk tales or to adapt the stories of Mahabharata and Ramayana for new readers. It was also all right to write hortatory materials on the various aspects of development because they could always team up with somebody from the Ministry of Agriculture or the Ministry of Community Development or with a specialist on poultry farming who would take care of the subject matter. In those cases, they didn't have to acquire any scientific literacy of their own. All they had to do was to read the material that was given to them, dilute it and write it down in readable form. After the book was done, they would show it to their subject-matter specialist to make sure nothing had been misrepresented.

A minimum curriculum for scientific literacy for adult learners

How do we go about teaching scientific literacy? A minimum curriculum for adult learners should include the material described below.

The chemistry of the human body should be the first element of such curriculum. What is this chemistry? How is it affected by what the human body consumes by way of food, water and air? The human body as a biological unit must be discussed next. Due attention should be given to the processes of human procreation. The attacks on the human body by its visible and invisible enemies which bring sickness and disease must be explained. This would mean some discussion of the germ theory and of the theory of immunization. Finally, the human body should be discussed as a physical machine with definite limits of tolerance and possibilities.

From the human body we should go to the earth from which human beings everywhere in the world draw their sustenance by growing food. The curriculum should include ideas on soil mechanics and soil chemistry so that the farmer can understand *why* the extension worker and the community development worker are telling him to do what they are telling him to do. He should be able to understand the logic of the instructions he is receiving about fertilizers, water, insecticides, row planting, soil erosion and dozens of other topics, depending on the local ecology.

The world of work outside the rural areas and our general technological environment should also be part of the curriculum. The physics of machines and the theories of energy should be taught. What makes a bulb light up? What makes a radio sing? What brings a picture to the TV screen? What makes a steam engine run or an airplane fly? What makes a motor on the tube-well spill out water? The mystifying and magical relationships between adults and their technological environment must be converted into systematic understandings.

Finally, the focus should shift to a thorough understanding of the environment. Here we should teach our adult learners about the water cycle, the carbon cycle and related ideas of conservation of matter. The delicate (and endangered) balance between man and his environment must be clarified

One of the monographs in *Literacy in Development*, the series of training monographs for middle-level literacy workers commissioned by the International Institute for Adult Literacy Methods, is directed to the subject of scientific literacy. It is hoped that once this monograph becomes available, it will be put to many different uses by literacy workers at various levels of responsibility: to make audio-visual materials, to organize demonstrations, to write radio scripts and follow-up books and, hopefully, to be used as a handbook for teaching scientific literacy to teachers and supervisors in training courses.

It has been implied all along that the effort should not be merely to give adult learners instructions based on scientific knowledge but to present the scientific ideas behind such instructions; to teach adult learners sets of ideas that can be used by them generatively to cope with the various aspects of the environment today; ideas which they can transfer from the situation in which they learned them to new situations which they have not yet faced or even anticipated. We must teach them both science and the scientific method.

Some policy recommendations

To promote the teaching of scientific literacy to adult learners, some policy actions must be undertaken:

1. First and foremost, Unesco should take initiatives in the promotion of scientific literacy among adult learners in the Third World. Clearly, scientific promotion is part of the Unesco mandate, and its work in the areas of 'high' science and school science has been quite impressive. But while Unesco has already paid special attention to science development in the Third World, it could do much more in the area of mass scientific literacy: teaching scientific literacy to adult men and women—farmers and workers.

2. The regional organizations of adult education such as the International Institute for Adult Literacy Methods in Tehran, Iran, can do much in addition to the publication of monographs to spread the teaching of scientific literacy.

3. Nationally, the obvious thing to do would be to appoint scientific literacy specialists within the policy-making sectors of adult education in each Asian country and elsewhere. This is not something that would necessarily require huge sums of additional money. It could often be merely a question of perspective and re-allocations. What is suggested is that in appointing officials who would make decisions about adult education within ministries, advisory committees, planning commissions and adult education directorates, we should think of appointing some who have scientific backgrounds. The task of the dissemination of scientific knowledge among adult learners and the new reading publics should become an important part of adult education and functional literacy.

4. We should also establish special cells within voluntary adult education associations to promote the teaching of scientific literacy. For example, the Indian Adult Education Association, while it has a distinguished history of leadership in adult education in the country, has not done much in this particular area. There is no reason why this and other adult

education associations in Asian countries should not establish separate wings on scientific literacy to assure that a portion of efforts and resources of each such association can be allocated to its promotion.

5. To be sustained, educational revolutions often require new textbooks and instructional materials - and teachers to be trained and provided with teachers' guides for scientific literacy. For adult literacy to have a chance, suitable books and instructional materials must also be provided both for adult educators and adult learners. Follow-up materials on scientific literacy for new literates should be given special attention. There are various prize schemes for writers of books for new literates which are already functioning in India and elsewhere, and which have proved to be quite successful in promoting writing for new readers. We should make efforts to establish such schemes in most countries of the Asian region and where such schemes already exist to increase the allocation of prizes for books which teach scientific literacy.

6. Schemes similar to India's Vigyan Mandirs (shrines to science) should be developed, and needed effort and resources should be allocated to such schemes. If successful, such projects can do a lot for the dissemination of scientific knowledge among rural communities.

7. Radio should, of course, be put to work in the dissemination of scientific ideas among adult learners. There is no reason why we should wait for the rural people to become visually literate before they can be given scientific literacy.

8. And finally, it is important that scientific literacy becomes an important part of the training of adult education and functional literacy workers themselves. To promote the scientific literacy of adult learners, we must begin with the scientific literacy of adult educators.

Conclusions

Recently, Western science has come under attack from 'humanists'. What they have said is that Western science has gone into traditional communities of the Third World and negated the knowledge that these people have used over the centuries. In addition to making the assumption that science is all Western, the preceding seems to present an alarmist view of the processes of intercultural diffusion of ideas. Every new idea need not reject an old one. The rational need not always destroy the intuitive or even the magical. History is indeed on the side of those who wish to promote scientific literacy. Science, as we know it, has often succeeded in getting fused with the social and cultural traditions of non-Western cultures. Peoples in the traditional cultures have been seen to go both to the town clinic and to the Devi temple for the cure of chickenpox; and earthquakes have been explained in these cultures in terms of both the geological faults and the Shiva's Bull that carries the earth on its horns - changing the burden from one horn to the other.

The dividends of scientific literacy of adult learners would be many. First of all, it would help communities and subcultures to review their old traditions and understand the scientific basis of their own procedures and prescriptions. Some of what is today merely the ritualized and the magical may become scientific and may, in turn, contribute to the total global fund of scientific knowledge.

Scientific literacy would also introduce a scientific way of thinking: a logical approach to problem-solving. Again, this does not necessarily mean the banishment of the intuitive from the lives of the peoples of the Third World; but it does mean that other-than-magical relationships with things and entities surrounding them will result.

Scientific thinking would also question the peoples' belief in the immutability of existing conditions by giving individual adult learners feelings of personal efficacy, ultimately contributing to collective optimism.

And finally, scientific literacy as proposed here would result in tremendous saving of labour in adult education and literacy programmes. As things are today, we go on teaching discreet facts of agriculture, health, family planning and farming to adult men and women as we meet them in our work. Every time a new programme is introduced, new instructions are given to the same people, but there is little of their learning that farmers can transfer from one situation to another.

How much can adult learners learn? Are we not all writing curricular prescriptions for adult learners to suit our special occupational biases for literacy, agricultural extension, cattle farming, industrial skills, trade-union education, family planning, nutrition education, child care, gardening, poultry farming, problem solving, co-operative education, arts and crafts, discussion methods, human relations or political education - and now scientific literacy? Yes, we are. But it is within human capacity to learn all this and much more. As long as we can relate these learnings to our learners' lives at home and at work, they will learn these new ideas almost effortlessly. Scientific literacy deserves special attention. Science is one of the most precious fruits of man's intuitive and rational capacities in harmonizing with nature to change the flow of rivers, to level mountains, to make deserts bloom, to alleviate physical pain, to manipulate time and space, and to make possible continued peaceable existence for the world's thousands of millions of people.

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EVALUATION IN SCIENCE EDUCATION AT THE FIRST AND SECOND LEVELS IN INDONESIA

by Ratna Wilis Dahar

Evaluating student progress in science

In education, evaluation refers to the process of determining the degree to which the objectives of an educational activity or enterprise have been achieved. The activity may be a large one, in terms of its duration and scope, such as an entire course or even a curriculum for producing persons with certain kinds of professional or general skill, or /it/ may be relatively restricted, such as the work of a single instructor with his group of adults over a period of a week or an hour. In either case, the evaluation process determines the degree to which the objectives . . . have been achieved. (1)

Although various aspects of educational programmes have been developed since Indonesia proclaimed her independence in 1945, not much has been achieved in the evaluation process, which actually plays an important role in the conduct and improvement of science education.

In 1972 an educational needs-assessment survey was conducted in order to identify the aims and objectives for the various levels of education. Based on this survey, two curricula were developed for primary and secondary education. One is known as the 1975 curriculum, introduced on a step-by-step basis in 1976 in grades I and IV of Primary School, the first grade of Junior High School, and the first grade of Senior High School throughout the country. By the end of 1978 all grades are to use this curriculum.

The Development School Project (DSP) has its own curriculum, which since 1975 has been implemented in the eight 'development schools' situated at eight localities: Jakarta, Bandung, Semarang, Yogyakarta, Surabaya, Malang, Padang and Ujung Pandang. The main aim of this project is to work out a better school system which is conducive to educational reform and would fulfil the needs for qualified manpower in the future. As the result of selecting the best teaching/learning strategy we have come to a new outlook, that individualized learning through modular instruction might be an alternative to introduce into the educational system. At the experimental stage, the DSP is trying to develop the modular approach under the co-ordination of the Office of Educational and Cultural Research and Development (BP3K). Up to the present time, modules have been written for five subject areas: science, mathematics, social studies, Bahasa Indonesia and English for almost all grades of the primary, junior high (junior secondary), and senior high (senior secondary) schools of the Development School Project.

The 1975 curriculum and the DSP curriculum are based on the concept that the teaching/learning process in the classroom is a system in itself. When viewed in this light, evaluation becomes an integral part of the teaching/learning process. Due to this systems approach, the 1975 curriculum requires every teacher to develop small units of instructional programme, called the unit lesson, which shows the various components of the instructional system. Until the present time, the modules had been developed by a national team of module writers.

Major steps in the evaluation process

The process of evaluation can be described in various steps.(1) In this article only the major steps of the process of evaluation as it is practised by the Indonesian classroom teachers or module writers will be discussed.

Step 1. Identifying and defining objectives in terms of desired changes in student behaviour

The first step in teaching and hence evaluation is that of determining the learning outcomes to be expected from classroom instruction or individualized instruction. What specific behaviour changes are we striving for? These specified behavioural objectives, known also as the specific instructional objectives, are derived from the general instructional objectives. The general instructional objectives formulated by the curriculum development team at national level, are comprehensive educational objectives following Bloom's "Taxonomy of Educational Objectives." (2)

The general instructional objectives are deduced from the curricular objectives, which in turn are deduced from the educational goals. Table 1 shows the sequence of the various objectives.

Table 1

Goals or objectives	Developed by
Educational goals	National team 1
Curricular objectives	
General instructional objectives	National team 2
Specific instructional objectives	Classroom teacher or Module writer

Although the general instructional objectives for the science courses at the first and second levels have been stated by the members of the national science team, our experience shows that many difficulties have arisen in the process of developing the specific instructional objectives. As shown in Table 1, the specific instructional objectives are formulated by the teachers in the unit lessons, or by the module writers in the modules. Bloom's "Taxonomy of Educational Objectives" is quite new for them, especially for the teachers. In the traditional science courses, teachers used to formulate objectives in terms of teacher activities, not in terms of changes in student behaviour.

Another reason is that specifying instructional objectives relevant to the general instructional objective needs time. This time factor can only be overcome if teachers don't have to teach so many classes.

It should be mentioned that, from the six aspects of Bloom's cognitive domain, only two - knowledge and comprehension - have been satisfactorily developed by the science teachers for the lower classes of the primary grades. For the higher classes, the aspect of application has also come into consideration. The aspects of analysis, synthesis and evaluation have not been so seriously stressed. By identifying objectives and stating them clearly in terms of specific behaviour we can provide direction to the teaching process and set the stage for ready evaluation of learning outcomes.

The objectives in the affective domain are usually not formulated in specific form, but left in general form. The reason for this is that we cannot expect a student to change his attitude after one lesson lasting for two or three periods, or after one module. It is hoped that after several lessons given by the teacher, or after using several modules, these objectives in the affective domain will be achieved. The change of behaviour in the psychomotor domain can be readily observed from the ways the students use the tools and equipments in science.

Step 2. Selecting situations and instruments which are most appropriate for observing and assessing to what extent the student has achieved the stated specific instructional objectives in science

In this step, the teacher or module writer is required to construct evaluation instruments which are relevant to the objectives stated.

Realizing the difficulties which will be faced by the teachers in the implementation of the new techniques in evaluation, several workshops have been held to give teachers additional information in this field. A booklet (3) has also been published by the Ministry of Education and Culture in May 1975 which functions as a guide for the teachers in evaluating student progress.

Step 3. Judge the degree to which the score obtained by the students reflects achievement of the objectives of the educational activity in science

There are two major approaches to making such judgements: the norm-reference and the criterion-reference approach. In the norm-reference approach, each student's score is compared with that of other students belonging to a norm group. In the past this approach has been frequently used. In the criterion-reference approach, the judgement of each student's score is made directly with reference to stated objectives.

The DSP curriculum uses the criterion-reference approach. A student may only start with the next module if he masters 75 per cent of the objectives in the module on which he is working. The extent to which each student masters the objectives is measured by the formative test that accompanies each module. If a student fails to achieve the 75-per-cent mastery level, he is required to do remedial work.

The 1975 curriculum also requires 75-per-cent mastery of the objectives stated in each unit lesson. A student who fails to achieve this 75-per-cent mastery may be allowed to participate in the next unit lesson, but he still needs remedial work or special guidance to overcome the difficulties in learning science.

Summative and formative evaluation

The most obvious means of assessing students' achievement have been provided by tests and examinations. In the past, the standard procedure in a science classroom was to administer a test after completion of a unit of study, of a group of related units, and of an entire course. The test results were used primarily as the basis for assigning grades; the main stress was given to summative evaluation. Although some science teachers in the Junior and Senior High Schools did sometimes use the results of the test to guide the students on how they should proceed next, it is only recently that widespread concern has been given to the immense positive value of formative evaluation.

In the DSP and 1975 curricula, formative evaluation has been stressed. The term 'formative evaluation' was first used by Scriver in 1967 in connection with curriculum development.(4) The aim of formative evaluation is to improve teaching and learning; therefore, the collection of data concerning the process of accomplishing instructional objectives should be undertaken as soon as possible after a certain programme is started. The result of this assessment should be fed back immediately to those concerned with development of the programme.

In the DSP curriculum, with its modular system, each student has to take a formative test at the end of each module. The test is constructed relevant to the stated specific instructional objectives and, again, a 75-per-cent mastery level is required. If students fail to achieve this, they repeat the learning activities related to the test items where they were unsuccessful. Sometimes special guidance is necessary to help students in mastering certain science concepts.

The frequency of the diagnostic tests may vary throughout the science course, depending on the number of modules prescribed for a certain grade. Table 2 gives the number of modules on science for each grade of the Development School. It also shows that the structure of the Development School is 5-3-3. At the end of each semester, except at the end of the second semester of grades V, VIII and XI, students have to take a summative test. This test is constructed by the members of the National Team of Evaluation and some module writers. The test would sample the totality of specific instructional objectives covered in the module, ensuring that every general objective was covered. In addition to this summative test, teachers are also asked to make an intermediate summative test after completion of a certain number of modules.

Table 2. Number of science modules for each grade

	Primary					Junior High			Senior High									
Grade	I	II	III	IV	V	VI	VII	VIII	IX	X				XI				Total
										Physics	Chemistry	Biology	E & S*	Physics	Chemistry	Biology	E & S*	
Number of Modules	10	14	18	18	24	18	19	24	30	15	10	11	3	25	21	18	4	282

* E & S = Earth and Space

The summative test plays a very important role in assigning grades to the students. If the modular system has attained its established stage, grades will depend mostly on the results of the summative tests. At this try-out stage, however, some consideration of the results of the formative tests will still be taken into account in evaluating students' work.

What has been discussed for the DSP Curriculum generally holds for the 1975 curriculum. Instead of having a formative test at the end of a module, the student of the regular school is required to take a teacher's formative test at the end of each unit-lesson.

Final examination

At the end of each educational level, students have to take a final examination. This final examination has two purposes: to act as a 'barometer' to measure the quality of education and to act as a selection device from one stage of education to the next.

Until 1968, the final examination was a State examination. In 1968, the Ministry of Education and Culture decided to substitute this State examination with a school-based examination. One aim of this change was to delegate more to schools the responsibility for improving the education that they provide. The first school-based examination was held in 1973.

There is a regulation issued by the Directorate General of Basic and Secondary Education (for the DSP the regulation is issued by the $\mathrm{BP_3K}$)(5) stating the criteria for determining whether or not a candidate passes the final examination. Students majoring in science will pass the examination if they fulfil a certain minimum requirement. The reason for having this minimum requirement is that the final examination should be a total evaluation and comprehensive in nature.

Evaluation techniques

Testing. Testing is the process of using evaluative devices to obtain quantitative measures of ability or knowledge. Tests are usually divided into two general types, the objective test and the essay test. The objective test is well known and useful, although its use is limited. It requires the students to supply just a word or two, or to select the correct answer from among a certain number of alternatives, while the essay test requires the students to select, organize, and present all of their knowledge on the subject in essay form.

Objective test items which require the students to supply the answer are of two types: (a) short answer and (b) completion. To the selection types of objective test items belong: (a) true-false or alternative response, (b) matching and (c) multiple-choice.

The essay test is commonly classified into the extended response type, where the students are given almost complete freedom in making their response and the restricted response type, where limitations are placed on the nature, length, or organization of the response. In the past, classroom tests were mainly of the essay type, especially in the secondary schools. It is only in the last few years that the multiple-choice test in science has been introduced in Indonesian classrooms. At present the multiple-choice item is generally recognized as the most widely applicable and useful type of objective test item. If well constructed, many shortcomings characteristic of the other objective types can be avoided. It tends to present a more well-defined problem than the short-answer item, it avoids the need for homogeneous material required by the matching item, and it reduces (but does not eliminate) the clues and susceptibility to guessing which are characteristic of the true-false item.

In addition to the kinds of tests mentioned above, the picture-test has been quite popular in science. Studies indicate that this kind of test is very useful, especially for students at the primary level, who still have verbal difficulties in science. To show the kinds of test items mainly stressed in final examinations, two final examinations in Chemistry of different years as printed in an evaluation guide are illustrated below.(6)

State Final Chemistry Examination 1960, Senior High School
Time required: 3 hours

I. 1. Describe the procedure to test phosphorus according to the Mitcherlich method.

2. How do ferrous ions and ferric ions react with:
(a) potassium thiocyanate; (b) potassium ferrous cyanide;
(c) potassium ferric cyanide?

II. 1. Which is more reactive, sodium or rubidium? Explain why.

2. Arrange the following elements according to increasing reactivity: (a) I, Cl, F, Br, At; (b) Li, Cs, K, Rb, Na, Fr.

III. 1. What is meant by:

(a) hydrophobic colloidal system; (b) hydrophilic colloidal system?

Give an example of each, and describe the procedure of preparing each colloidal system.

IV. 1. Write the molecular formula of a fat containing oleic acid.

2. Write the reaction of the hydrolysis of this fat.

3. Write the reaction of solidifying this fat.

V. In 300 gr water are dissolved 0.46 gr alcohol and 10 gr of another non-electrolyte. The freezing point of this solution is $-0.37^{\circ}C$. Calculate the molecular weight of this non-electrolyte. (The molal freezing point depression constant for water is $18.5^{\circ}C$).

$C = 12 \qquad H = 1 \qquad O = 16$

VI. How do we separate the components of a racemic mixture? Based on its structural formula, how do we know that an organic compound is optically active? Give an example.

VII. 1. 200 ml 0.01 N hydrochloric acid is added to 300 ml 0.01 N ammonia.

(a) What is the pH of the mixture?
(b) What is the pH of each solution before mixing?

$K_{ammonia} = 10^{-5} \qquad K_{water} = 10^{-14}$

State Final Chemistry Examination 1972, Senior High School
Time required: 2 hours

I. Select the best answer:

1. When the heat of combustion of ammonia is 54 kcal, the heat of reaction of $NH_3 + O_2 \longrightarrow NO + H_2O$

   will be: (a) 108 kcal; (b) 54 kcal; (c) 216 kcal; (d) 27 kcal?

2. At a certain temperature, N_2O_4 is 60% dissociated; its vapor density at that temperature is:
   (a) 28.7; (b) 14.3; (c) 46.0; (d) 73.6?

3. 0.23 gr sodium is dissolved in 100 gr water. The freezing point of this solution is -0.3534°C. When the molal freezing point depression constant for water is 18.6°C, the degree of ionization of NaOH in this solution is (Na = 23):
   (a) 0; (b) 0.9; (c) 0.1; (d) 1?

4. Among the following salts, which will be hydrolized when dissolved in water:
   (a) KNO_3; (b) KCN; (c) K_2SO_4; (d) KCl?

5. What is the ionization constant of a 0.01 N solution of acetic acid which is 25% ionized:
   (a) 6.25×10^{-4}; (b) 8.3×10^{-4}; (c) 2.5×10^{-3}; (d) 0.25?

6. The substance used to determine the end point of a titration is called:
   (a) catalyst (In Indonesian, katalisator);
   (b) oxidation agent (In Indonesian, oksidator);
   (c) reducing agent (In Indonesian, reduktor);
   (d) indicator (In Indonesian, indikator)?

7. The bond formed between two atoms by sharing a pair of electrons is called:
   (a) covalent bond; (b) ionic bond; (c) metallic bond;
   (d) Van der Waals' bond?

8. The reaction that can proceed is:
   (a) $Cl_2 + KI$; (b) $Br_2 + KCl$; (c) $I_2 + KCl$; (d) $I_2 + KBr$?

9. When Zn, Mg and Fe react with an acid, it will be observed that: (choose one answer)
   (a) Zn reacts faster than Mg and Fe;
   (b) Mg reacts faster than Zn and Fe;
   (c) Fe reacts faster than Zn and Mg;
   (d) All three react at the same rate.

10. After an element emits sipha particles, a new element is formed which has:
    (a) an atomic number of two less and a mass number of four more;
    (b) an atomic number of two more and a mass number of four less;
    (c) an atomic number of two more and a mass number of four more;
    (d) an atomic number of two less and a mass number of four less?

II. 1. Write the structural formula of:
    (a) 2-hydroxy propane tricarboxilate 1, 2, 3;
    (b) p-phenol sulfonic acid.

2. Write the equations for the following reactions:
    (a) the oxidation of isopropyl alcohol to acetone;
    (b) the preparation of ethyl acetate from the appropriate alcohol and acid.

3. Write the equation for the preparation of acetic acid from calcium carbide.

III. 1. Write the equations for the following reactions:
    (a) potassium manganate and chlorine;
    (b) aluminium chloride and potassium hydroxide in excess;
    (c) cupric sulphate and ammonium hydroxide in excess.

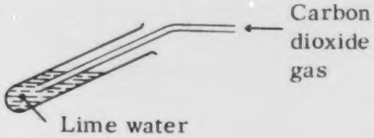
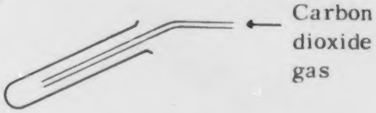
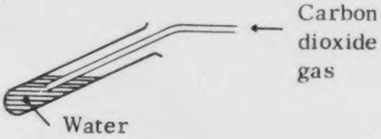
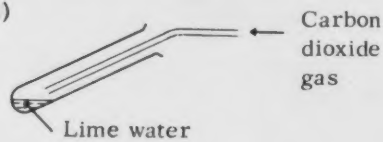
2. In the realization of the Five-Year Plan, Indonesia manufactures sulphuric acid from pyrite using the contact process.
    (a) Write all the reactions involved in this process;
    (b) How much pyrite should be consumed to prepare 25 kg sulphuric acid solution with a concentration of 95% by weight?

IV. 1. A sample of soil weighing 1.43 gr contains limestone. This soil is dissolved in an excess of hydrochloric acid solution. After filtering, the solution is diluted to make 250 ml. To 25 ml of this solution is added an excess of ammonium oxalate. The calcium oxalate which precipitated is filtered, washed, and then dissolved in an excess of suphuric acid solution. This solution is oxidized with 35.9 ml 0.01 N Potassium permanganate solution.
    (a) Write all reactions that occur;
    (b) How many per cents calcium carbonate is present in this soil? Ca = 40 C = 12 O = 16

An illustration will be also given of a chart developed by a module writer to ensure the relevance of the specific instructional objectives with the items in the formative test. It is expected that all science teachers use similar methods in developing their unit lessons.

Title of module : The Air Around Us (Grade V)

Specific instructional objectives	Test item
1. The student should be able to prove that air exists.	1.1 To prove that air exists, we (select) a) Compile pieces of wood, then burn them; b) Take a piece of thick paper and move it back and forth towards us; c) Take pieces of paper and throw them; d) Take a glass of water and pour it on the ground.
2. The student should be able to prove that air occupies space.	2.1 To prove that air occupies space, we: a) Lower a drinking glass mouth-downward into a vessel of water; b) Hold a drinking glass in a vessel of water; c) Hold a drinking glass filled with water and turn it over in a vessel; d) Hold a drinking glass filled with water in a vessel of water.
3. The student should be able to mention the names of substances found in air.	3.1 All of these substances are found in air, except which one(s)? a) Carbon monoxide; b) Oxygen; c) Nitrogen; d) Carbon dioxide
4. The student should be able to mention the approximate amount of each component of air.	4.1 When in a closed vessel we find 750 ml of air, then the amount of oxygen in that vessel is about: (a) 10 ml; (c) 100 ml; (b) 50 ml; (d) 150 ml? 4.2 When in a closed vessel we find 1,000 ml of air, then the amount of nitrogen is about: (a) 800 ml; (c) 400 ml; (b) 600 ml; (d) 150 ml.

Specific instructional objectives	Test item
5. The student should be able to give an example to show that air is necessary in burning things.	5.1 One example to show this is: a) a candle is lighted and then put on a table; b) a candle is lighted, then covered with a bell jar tightly; c) a candle is lighted, and then blown out; d) a candle is lighted, then put on a lower place.
6. The student should be able to mention two uses of oxygen.	6.1 Mention two uses of oxygen
7. The student should be able to prove at least one property of carbon dioxide.	7.1 To prove that carbon dioxide exists, we do as is shown in which diagram: a)  Carbon dioxide gas Lime water b)  Carbon dioxide gas c)  Carbon dioxide gas Water d)  Carbon dioxide gas Lime water
8. The student should be able to mention two uses of carbon dioxide.	8.1 Mention two uses of carbon dioxide.

Specific instructional objectives	Test item
9. The student should be able to explain that nitrogen is important for our life.	9.1 Nitrogen is important for life because it is (which is true?): a) necessary for breathing; b) present in substances needed for the development of new cells; c) necessary for producing carbohydrate; d) necessary for producing new cells.

Non-test evaluation. Although a large number of learning outcomes in science can be measured by paper-and-pencil tests, important behavioural changes require the use of other procedures. Some of the procedures practised by science teachers are:

1. Observing students as they perform, and describing or judging their behaviour;
2. Observing and judging the quality of the product resulting from their performance.

These observational techniques are subjective, and their use frequently requires more time and effort than the typical testing procedure. Rating scales and checklists provide a systematic procedure for obtaining and reporting the judgements of observers.

A rating scale and a checklist are similar in appearance and use. The basic difference between them is in the type of judgement called for. A rating scale provides an opportunity to indicate the degree to which a characteristic is present or the frequency with which an action occurs. A checklist, on the other hand, is basically a method of recording simply whether a characteristic is present or absent.

Rating scales and checklists are used by science teachers to evaluate students' performances in the laboratory, such as the skill to use the microscope, titration apparatus or skills used during field work. Besides evaluating the procedure of how to manipulate a piece of laboratory equipment, a rating scale or checklist is also used to judge the quality of an item of science apparatus a student has produced.

There are many occasions where students have an opportunity to show their achievements in producing a science apparatus or a science project, such as at the end of an academic year or at an anniversary of a University or Institute. The Institute of Teacher Training and Educational Sciences (IKIP) in Bandung, for instance, holds a science exhibition or science fair every year. High-school students are asked to participate in these activities.

In concluding this article, it should be said that we still have to work hard in solving many problems of evaluation in science.

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SECTION FOUR

BIBLIOGRAPHICAL SUPPLEMENT

INTERNATIONAL, REGIONAL AND NATIONAL (ASIAN COUNTRIES) CONFERENCES, MEETINGS, SEMINARS AND WORKSHOPS INVOLVING SCIENCE EDUCATION

This bibliography updates the one which appeared in the *Bulletin of the Unesco Regional Office for Education in Asia* IV(1): i-xxv, September 1969. It is based on documents in the Library of the Unesco Regional Office for Education in Asia.

1970

Asian Regional Workshop on the Progress of Integrated Science Teaching, Manila, Philippines, 3-17 August 1970. *Integrated science teaching in the Asian region, final report.* Bangkok, Unesco Regional Office for Education in Asia, 1971. 44 p.

The Workshop met to review progress in the teaching of integrated science in Asian countries and outside the region and to consider their relevance and applicability to Asian countries; to suggest guidelines for future developments in the teaching of integrated science; and to draw up a plan of action to foster collaboration in this field among countries participating in the Workshop. The level of work discussed at the Workshop covered the teaching of science as an integrated subject during the first eight or nine years of schooling. The Workshop suggested ways in which suitable programmes of integrated science could be devised, tested and implemented.

Conference of Ministers of the European Member States Responsible for Science Policy (MINESPOL) Paris, 22-27 June 1970. *Final report.* Paris, Unesco, 1970. 43 p.

The Conference examined current trends of national science policies in Europe in relation to manpower problems in science and engineering, and the choice and organization of scientific research priorities with concern for problems encountered at the national level and improvement of European co-operation in this field.

With regard to educational reform it was observed that educators generally are concerned with long-term values rather than with specific and immediate needs, and that they are sometimes hesitant to introduce innovations and adapt curricula and methods to the needs of a constantly changing situation. The Ministers expressed the conviction that science and technology must be "humanely conceived and wisely exploited to avoid the risk of demeaning mankind and despoiling his surroundings." Recommendations were made for broadening the basis, both cultural and scientific, of the education offered in science and technology, as well as strengthening the scientific and technological courses available to those pursuing studies in the humanities and social studies. Opportunities for continuing education, guidance and career development as well as provision of improved information and statistics for scientists and technologists were also recommended to enable scientists to keep abreast of developments in their own and related disciplines.

The Economic Commission for Africa (ECA)/Unesco Regional Symposium in the Utilization of Science and Technology for Development in Africa, Addis Ababa, 5-16 October 1970. *Final report.* Paris, Unesco, 1971. 49 p. (Unesco SC.WS/428)

The agenda considered the following aspects of science and technology: Policy-making and planning, Human resources, Natural resources, Industrial research and development, Infrastructure and Regional co-operation. Discussions on an educational infrastructure for science and technology pointed out that insufficient attention was given to these subjects in pre-university education as well as in adult education, and that scientific preparation should begin in childhood. Scientific information should appear in mass media to influence the mentality of adults and the life of developing countries. Recommendations were made not only for the improvement of training of scientists and technologists, but for science education that would enable students to acquaint themselves with their own country's socio-economic realities as well as their particular environment.

SEAMEO-RECSAM* Seminar /on/ Science Curriculum Development and Evaluation in Southeast Asia, Penang, 15-19 September 1970. *Final report /of the Seminar/ convened with the co-operation of the Government of Malaysia.* Penang, SEAMEO-RECSAM, 1971. 2 v.

The latest trends in science curriculum development and evaluation within and outside the SEAMEO region were reviewed. To examine a proposed course presented by RECSAM for each of the science disciplines including integrated science for secondary schools, the participants were divided into five workshops. The reports of each workshop provided specific guidelines for science and mathematics courses, an analysis of teaching/learning needs to be catered for and recommendations as to what RECSAM should do in terms of training key personnel.

1971

Co-ordinating Meeting for Unesco's Programme in Integrated Science Teaching, Unesco, Paris, 10-12 May 1971. *Final report.* Paris, Unesco, 1972. 30 p. (Unesco SC/WS/33)

Unesco's programme in integrated science teaching was reviewed. Particular attention was given to discussions on the concept of integrated science teaching, the learning process and the teaching of integrated science, and teacher education for integrated science. Proposals for Unesco's programme called for Unesco to serve as a catalyst enabling those involved in integrated science teaching to know what each other is doing through an information network, as many science project leaders work in semi-isolation.

Educational Research Workshop on Science Teaching in Asia /13 February-12 March 1971, Tokyo, Japan/ *Final report.* Tokyo, National Institute for Educational Research, 1971. 82 p. (Unesco-NIER Regional Programme for Educational Research in Asia)

Country papers reported efforts being made towards the modernization of science education at the primary school level. The participants explored possibilities of conducting a joint study on the elementary approach to science with special emphasis on problems of how to make scientific activities appealing to children or pupils. The participants also carried out a science experiment on 'Dissolution' to study its suitability as one of the central themes for teaching science in primary schools. Recommendations were made for initiating science education research and encouraging the bilateral exchange of research findings in science education.

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* SEAMEO-RECSAM stands for the Regional Centre of Education in Science and Mathematics of the Southeast Asian Ministers of Education Organization. The acronym is used in this bibliography.

[SEAMEO-RECSAM] Seminar for Senior National Administrators in Southeast Asia, Glugor, Penang, 17-22 March 1971. *Final report [of Seminar] convened with the co-operation of the Government of Malaysia.* Glugor, Penang, SEAMEO-RECSAM, 1971. 2 v.

The Seminar acquainted senior government and administrative officials in the region with: (1) new developments in education to enable them to give positive support to the planning and implementation of their national and regional programmes in science and mathematics, (2) how programmes are conducted at RECSAM, (3) guidelines for improvement of communication and co-ordination of national and regional efforts in developing curriculum reforms in the region.

SEAMEO-RECSAM Seminar [on] Research in Science and Mathematics Education in Southeast Asia, convened with the Co-operation of the Government of Malaysia, 1-7 October 1971. *Final report.* Penang, SEAMEO-RECSAM, 1971. 236 p.

The aim of the Seminar was to analyse current research programmes, exchange information and give guidelines for future research. Matters given immediate attention included: Effects of examinations on learning and learning strategies, Evaluation of teacher-training programmes, Classroom practice, Science/mathematics equipment.

SEPA (Science Education Programme for Africa) Teacher Training Materials Workshop, Nairobi, Kenya, 9 August to 3 September 1971. *Report.* Accra, Ghana, SEPA, 1971. 177 p.

During the years 1963 to 1967 groups of scientists, educators, Ministry of Education personnel and teachers co-operated at international workshops in Nigeria, Uganda, Tanzania, Ghana and with detailed work at science centres in Ghana, Kenya, Malawi, Nigeria, Sierra Leone, Tanzania and Uganda to prepare written teachers' guide materials for all grades in the primary schools. As the materials became available in schools, the need for extensive in-service teacher education/training was highlighted.

This Workshop held in Nairobi concentrated on the development of materials for teacher education and was approached in the same way as that adopted for preparing teachers guides for primary classroom materials in the workshops held in the 1960s. The Workshop prepared a Guide to the Study of Environment and studied existing instruments for evaluating classroom interaction. Viewpoints of the participants on fundamental issues in teacher education as well as papers prepared for support and stimulation of teacher training college students are included.

Sub-Regional Conference on Curriculum Development, University of the South Pacific, Fiji, 28 June to 10 July 1971. *Changing the curriculum, report [of the] Conference sponsored by the South Pacific Commission, Unesco and the University of the South Pacific.* Noumea, New Caledonia, South Pacific Commission [1971?] 153 p.

The opening remarks of the Prime Minister of Fiji, Ratu Sir Kamisese Mara, highlighted two of the more pervasive problems in curriculum design for developing countries: the problem of relating needs of the individual learner to national needs and the problems associated with dependence on outside experts in curriculum development which may not always provide solutions for the first problem nor provide opportunity for the nationals to extend themselves so as to increase their own capacities for constructive thought.

The Conference, through different subject groups which included a science group and a mathematics group, considered how a greater awareness of the need for curriculum change might be promoted within the area. The science group worked on: guidelines for setting up objectives of courses, criteria for selection of course content, development of teaching materials sample instructional units; and considered the areas of evaluation and examinations, teacher training, educational facilities and equipment.

/Unesco/ Advisory Meeting on International Exchange of Information on Science Education Improvement, Paris, 13-14 May 1971. *Report*, Paris, Unesco, 1971. 6 p. (Unesco SC/WS/34)

The discussions centred on: What is educational information? What information is needed and for what purpose? It was felt that clarification of these questions is necessary to planning the collection and dissemination of information. The participants were briefed on the current state of information technology and on current activities of leading education information services. Possibilities for increasing the scope and usefulness of the information services given by Unesco's Division of Science Teaching were also discussed.

Workshop for Science Education Programme Planners in English-speaking African Countries, Ibadan, Nigeria, 20 September-4 October 1971. *Planning for integrated science education in Africa /a report of a regional workshop/* Ibadan, Unesco /1971?/ 72 p. illus.

Participants from 14 African countries met to exchange information on current projects and programmes aimed at implementing the integrated science curricula for the first eight or nine years of schooling, in English-speaking African countries. The participants divided themselves into working groups to work on each of the following: to spell out a clear concept of what integrated science includes, to develop a guide for curriculum planning for integrated science teaching in a hypothetical African country and construct a specimen lesson, to draw up specifications for a prototype integrated science teaching laboratory as well as explore possible teaching/learning resources in the light of production, servicing and utilization. The Group covering teacher education prepared specimen teaching materials for orienting teachers in service or for training towards an integrated approach to their teaching.

1972

Asian Expert Seminar on the Development of Science/Mathematics Concepts in Children, Bangkok /Thailand/ 29 May-10 June 1972. *The development of science and mathematics concepts in children, final report of the Seminar convened by Unesco and UNICEF in association with CEDO.* Bangkok, Unesco Regional Office for Education in Asia, 1972. 102 p.

The foreword of the report poses some of the following pointed questions: "Do children always learn what we /educators/ consider important?".

Are students ... always capable of understanding what the curriculum demands of them? How much is known about Asian children's cognitive development, and are there significant differences between children from one country to another; between children from urban and rural areas, from different cultural backgrounds? How far is the curriculum being designed to take account of important variations in the way children think from pre-school age to secondary age. What impact do existing curriculum projects and programmes have on the child? It was on questions such as these that participants in this Seminar deliberated in order to identify learning problems and useful experiences including research carried out in the field of concept development in science and mathematics in children (age range 3-11/12 years).

Demonstration on how children are interviewed were given with groups of children followed by discussions on approaches that could be used in investigating concept formation in children. The final concern of the participants was to consider ways and means by which the findings of research may be fed into practical curriculum development work in science.

Asian Regional Seminar on the Promotion of Public Understanding of Science and Technology, Manila, Philippines, 25 September-2 October 1972. *Final report.* Manila, Unesco National Commission for the Philippines, 1972. 116 p.

The Seminar is one of a series of activities of the Unesco National Commission for the Philippines to implement a recommendation made at the Ministerial Conference on the Application of Science and Technology to the Development of Asia (CASTASIA) held in New Delhi in 1968. The recommendation considered for priority action called for the promotion of appreciation of science by the common man through various media, activities and organizations with special emphasis of reaching the rural population. The papers and discussions covered the role of science education including out-of-school science activities in promoting appreciation and understanding of science and technology.

Evaluation Panel on Unesco Pilot Project for Chemistry Teaching in Asia (1965-1970) Bangkok, 24-28 January 1972. *Final report and evaluation.* Paris, Unesco, 1972. 85, 10 p. (Unesco/WS/505) mimeo.

In 1965 the Unesco Pilot Project for Chemistry Teaching in Asia was sited in Bangkok in a Centre for innovative activities with science education leaders in Asia. After its five-year programme, a panel was convened composed largely of former Pilot Project participants to review the objectives and outcomes of the course and to recommend to science educators in the region and to Unesco appropriate future courses of action to foster improvement in the teaching of chemistry.

Implications for future planning of science education improvement in Asia as reflected by the panel's evaluation seemed to indicate: that people involved in curriculum reform at the operational level are not involved in decision making; that effort should be concentrated on the development of local material closely related to needs, capabilities and aspirations of the individual countries; that there is no effective mechanism that can ensure the identification and involvement of local experts and institutions in the matter of curriculum development; that the adoption of new teaching technology should be done with due regard for the ability to both afford and exploit it.

Science education in the Asian region

Fourth Asian Regional Conference in Biological Education, Jerusalem, August 1972. *Proceedings.* Quezon City, Philippines, Asian Association for Biology Education Secretariat, Science Education Center, University of the Philippines, 1972. 612 p.

While the first three conferences of the AABE were devoted to the content and problems directly related to biology teaching and biological education, this fourth Conference widened the scope of AABE's concerns to include more general problems which are of interest to the teaching of biology as well as to other sciences and to modern education in general. The participants, including science educators not only from Asia but from Africa, U.K. and U.S.A., concerned themselves with methodologies curriculum development, the training of teachers, general aspects of learning, teaching, testing and the utilization of educational technology.

International Seminar on the Implementation of Curricula in Science Education with Special Regard to the Teaching of Physics, University of Kiel, 16-18 March 1972. *Report [of the Seminar] organised by the German Commission for Unesco and the Institute of Science Education at the University of Kiel.* Epping, Essex, Bowker, 1974. 207 p.

Meeting of Leaders of Science Teachers Associations, 12-17 June 1972, Singapore. *Final report [of the Meeting] convened by Unesco in collaboration with Singapore National Commission, Singapore National Academy of Science, Science Teachers Association of Singapore.* Singapore National Commission for Unesco, 1972. 41 p.

This Meeting was a direct outcome of a recommendation made at the Unesco Workshop on the Progress of Integrated Science Teaching in the Asian region held in Manila in 1970. The Meeting reviewed and discussed the objectives, structures, finance, professional relationships with other bodies, publications, major meetings, activities in curriculum development and teacher education, special programmes and projects, as well as problems of the associations.

Regional Meeting for Science Education Improvement in Asia, 20-28 November 1972, Tokyo. *Final report.* Tokyo, Japanese National Commission for Unesco, 1973. 54 p. (Unesco Regional Project for the Improvement of Science Education in Asia)

This Meeting discussed: Ideas, information and experiences involved with the design and implementation of national projects for science education improvement; Common needs and problems as well as innovative methods to solve teaching/learning; A co-operative action programme for science education improvement.

Regional Seminar on School Science Equipment [in Asia] New Delhi, 11-20 December 1972. *School science equipment, final report.* Bangkok, Unesco Regional Office for Education in Asia, 1973. 65 p.

The Seminar, attended by curriculum developers, equipment design specialists and specialists in manufacturing of science education equipment from countries in the Asian region focused attention on problems of design, prototype manufacturing, mass production, marketing and distribution of science equipment. The training of teachers and laboratory technicians in the use of modern equipment was another concern of the Seminar. It was emphasized that science should be presented as 'Doing' and 'Understanding', and should involve students in the improvization of equipment and designing of experiments.

SEAMEO-RECSAM Seminar /on/ Strategies for Curriculum Development in Southeast Asia, 14-20 March 1972. *Final report /of the Seminar/ convened with the co-operation of the Government of Malaysia.* Glugor, Penang, SEAMEO-RECSAM, 1972. 210 p.

The observation was made that examinations are strongly entrenched in the education systems in Asia, and it would be useful to take advantage of these instruments to stimulate and accelerate curriculum development and improve the quality of education. The query was posed as to how educators can reform examinations in order to bear on curriculum development and bring about real qualitative improvements in education.

Unesco-RECSAM Workshop, Penang, Malaysia, 31 July-12 August 1972. *Integrated science teaching in Asia, final report.* Penang, Malaysia, RECSAM /1972/ 102 p.

Representatives from Asian countries met to exchange experiences in integrated science teaching and to share ideas in the development of relevant instructional materials and innovations for schools and teacher education programmes. The participants also deliberated on strategies for the production of low-cost and effective science equipment for the teaching of integrated science. The report covers the following: Section I, The status of integrated science education in South East Asia. - Section II, Three approaches to integrated science curricula: The conceptual approach, the environmental approach, the process approach. - Section III, Suggested activities and materials for the education of teachers of integrated science. - Section IV, Equipment development and production for integrated science courses. - Section V, Audio-visual materials for integrated science teaching. - Section VI, Recommendations.

1973

International Conference on Education of Teachers for Integrated Science, 3-13 April 1973, University of Maryland, U.S.A. *Teaching science for today's society /report of the Conference/ organized by the International Council of Scientific Unions in collaboration with University of Maryland, Unesco and the US National Commission for Unesco.* London, CEDO /1973?/ 59 p.

Since the Varna Conference in Bulgaria in 1968, integrated science has received increasing attention in many parts of the world. The interest has been so great and the empirical progress so rapid that there has been scarcely time to pause and examine how best to prepare teachers for tackling the task of teaching science in an integrated way. The lectures in the plenary sessions of this Conference were an important source of information and ideas, but it was in the working groups where questions such as the following were thrashed out: New approaches to the preparation and in-service training of teachers._ New materials for the education of science teachers._ Roles of science teachers' associations, science inspectors and advisers._ Evaluation of programmes for the education of teachers._ Aims and objectives of teacher education for integrated science._ Science teaching improvement projects and centres: the preparation of teachers.

Regional Seminar on Review of RECSAM's Progress and Programmes for 1975-1980. *Final report,* /of the Seminar convened by RECSAM with the co-operation of the Government of Malaysia held in Glugor, Penang, 18-22 June 1973/ Penang, SEAMEO - Regional Centre for Education in Science and Mathematics (RECSAM) 1973. 86 p.

This report reviews RECSAM's activities and programmes for the years 1968-1972 and provides suggestions and plans for RECSAM to help the SEAMEO countries improve science and mathematics education.

[SEAMEO-RECSAM] Seminar on Development of South East Asia Primary Science Project, Glugor, Penang, Malaysia, 12-16 March 1973. *Final report of the Seminar convened by SEAMEO-Regional Centre for Education in Science and Mathematics with the co-operation of the Government of Malaysia.* Penang, SEAMEO-RECSAM, 1973. 240 p.

The role of RECSAM in accelerating the pace of curriculum development through its Primary Science Project was reviewed. Of special concern to the participants was finding ways to present science to children and all involved as an essential part of human and social development rather than as cold scientific facts alien to everyday life.

1974

National Seminar on Science Teachers Associations, Penang, 25-27 February 1974. *Final report.* Kuala Lumpur, Ministry of Education and Malaysian National Commission for Unesco, 1974. 31 p.

The participants of the Seminar were briefed on the activities and projects of the Malaysian Science Teachers Association organized in 1966 which include keeping a strong link with the Ministry of Education, publication of a Newsletter and a Bulletin, maintaining a library, holding seminars, co-operating with the Ministry of Education in science curriculum development, organizing Science Fairs where meaningful research projects are encouraged among pupils. Case studies of science/mathematics teachers associations in Ghana, U.K. and U.S.A. were also presented. The resolutions of the Seminar called for forming the Malaysian Association for Science and Mathematics Education.

Regional Seminar on the Development of Science and Mathematics Concepts in Young Children in African Countries, Nairobi, 17-27 September 1974. *Final report* [of the Seminar] Nairobi, Unesco-Unicef, 1974. 96 p.

The participants in reviewing the extent of Piaget's work and influence in studies in Africa observed that Piagetian theory and the growing body of knowledge related to it provide the most useful framework within which to undertake emperical research on the intellectual development of children and to apply research findings to the content, pace, and method of the curriculum. The Seminar enabled the participants to observe as well as try out for themselves experimental techniques of interviewing children. These were video-taped and reviewed by the participants.

1975

*[APEID] Preparatory Working Group Meeting [on Science Education] Seoul, Republic of Korea, 7-12 July 1975. *Science in basic functional education: philosophy, approaches, methods and materials.* Bangkok, Unesco Regional Office for Education in Asia, 1975. 49 p.

Report of a meeting held in the Republic of Korea in July 1975 to discuss issues in science education, to develop a 'philosophy' of science education and to suggest guidelines for instructional programmes and for the preparation of modules. Science education is one of APEID's six major programme areas and its philosophical foundation is documented in this publication. On that basis, the role of the teacher in science education is spelled out and appropriate methods, materials and media are discussed.

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* APEID stands for Asian Programme of Educational Innovation for Development; the acronym is used in this bibliography.

/APEID/ Technical Working Group Meeting /on Co-operative Development and Production of Exemplar Modules on Science Education/ 26 November-11 December 1975, Manila, Philippines. *Science in basic functional education: Links with real-life situations*. Bangkok, Unesco Regional Office for Education in Asia, 1975. 40, xv p.

The Group's deliberations focused on the content of science education at the first-level of education, its organization by discipline and the most effective approaches to its delivery. The links between science and real life were examined through an analysis of several selected situations in the areas of rural transformation, health and nutrition and employable skills. Included in the report are several recommendations related to the production of exemplary modules for science education.

1976

/APEID/ Module-Writing-Workshop on Science in the Rural Environment, New Delhi, India, 29 November-18 December 1976. *Science in basic functional education, report /of the Workshop/* convened by /The National Council of Educational Research and Training, India and ACEID/ Bangkok, Unesco Regional Office for Education in Asia, 1977. 31 p.

The participants of the Workshop met to share their experiences in working out ways to link science education to real-life situations. Problem areas in the rural environment were identified for developing relevant self-learning exemplary modules. The Workshop recommended that the Member States utilize the module-writing experiences of the participants of the Workshop, as well as test the modules developed and analyze results.

Regional Meeting on the Trends and Problems in Science and Technology Education in Asia, Singapore, 20-26 July 1976. *Report*. Bangkok, Unesco Regional Office for Education in Asia, 1976. 46 p.

This meeting made a stride forward in popularizing the current concept of science/technology learning - the concept of beginning in the soil and in the shop. After reviewing current trends and problems in science and technology in their countries, the participants examined inter-relationships between community-based science and technology education. They made recommendations for co-operative action programmes. The report in words and photographs shows students and out-of-school youth in their natural surroundings in Asia, the ideal starting point for science learning.

Sixth Biennial Conference of the Asian Association for Biology Education, Bangkok, 28 July to 2 August 1976. *Preparation of teachers and resources for biology teaching /working papers/* Bangkok, AABE, Institute for the Promotion of Science Teaching (IPST) 1976. (various papers, various paging)

Each day of the Conference was devoted to various aspects of teacher education, starting with a lecture and including contributions of country papers. The topics discussed were: Challenges in the structure and method of the preparation of biology teachers, How are the teacher education curriculum and strategies for training made relevant for biology teaching? The development and utilization of indigenous resources, teaching resources, the biology teachers' role and responsibilities, Associations and regional teacher training centres, How they make biology teaching more effective and relevant.

1977

/APEID/ Programme Development Meeting, Chiangmai, Thailand, 26 April-6 May 1977. "Area of innovation: Science (including mathematics) and technology education" in *Report on work plans of APEID for the second programming cycle (1978-1981).* Bangkok, Unesco Regional Office for Education in Asia, 1977. p. 121-128

The main emphasis of this area is on innovations in science (including mathematics) and technology education related to national development goals with reference to integrated rural development; development of productive skills relevant to economic development; universalization of education at the early school level and functional education for out-of-school youth and adults, good health and nutrition, and environmental education (including care and conservation of natural resources). Activities to bring about necessary outcomes are time-tabled.

Fourth Regional Consultation Meeting on the Asian Programme of Educational Innovation for Development /APEID/ Bangkok, 19-25 April 1977. "Programme area: Science education" in *Evaluative review and recommendations for the second programming cycle, final report.* Bangkok, Unesco Regional Office for Education in Asia, 1977. p. 34-37

In the broad field of curriculum, science education has been an important concern of almost all Member States in Asia. Major priority was accorded in APEID to developing the programmes of science in basic education, linking science education to environment, to the problems of everyday living and to rural development. To determine how these programmes may be further developed during the second cycle of APEID, an evaluative review was made of the work accomplished during the period 1975-1977, the reports and publications issued and the work in progress. The Meeting expressed the desire "that the Programme Development Meeting (PDM) take ... environmental education (including care and conservation of natural resources) into account while developing work plans..."

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STUDIES IN SCIENCE EDUCATION

This bibliography updates the one which appeared in the *Bulletin of the Unesco Regional Office for Education in Asia* IV(1): i-xxv, September 1969. It is based on documents in the Library of the Unesco Regional Office for Education in Asia.

Asia

Comber, L.C. and John P. Reeves. *Science education in nineteen countries, an empirical study.* New York, John Wiley, 1973. 403 p. (IEA International studies in evaluation I)

The Unesco Member States in the Asian region included in this study are Australia, India, Iran, Japan, New Zealand, and Thailand. The study examines the factors accounting for differences between countries and within countries and how these differences operate in relation to the socio-economic, cultural and educational environment of the student. The effects of comparative retentivity or holding power of the various school systems, the differences in achievement and interest in science between boys and girls, and social bias at the upper secondary level are also studied.

Australia

Field, T.W. *Cognitive style, critical thinking and science orientation.* (Ph.D. thesis) Armidale, University of New England, 1971.

Knight, A.C. *An examination of the science courses at the upper primary level in Western Australian government schools.* (M.A. thesis) Nedlands, University of Western Australia, 1970.

Owen, John M. *The effects of schools on achievement in science.* Hawthorn, Australian Council for Educational Research, 1975. 90 p. (IEA Australia report 1975:1)

This study examined the effects of science teaching and facilities over a period of years on the achievement of senior secondary school students in one state of Australia. The methods used in this study provided a means by which variables which affected achievement in science were uncovered and examined.

Pascoe, Robert and Ron Shepherd. "Do student opinions really matter?" *The Australian Science Teachers Journal* 20(1):97-99, May 1974.

Nearly all the 40 units which have been produced by the Australian Science Education Project (ASEP) were tried out in schools throughout Australia before final publication. To evaluate the trial version of each unit, information was collected from a variety of sources, including results of evaluative diagnostic tests, opinion scales, and comments by students, teachers, observers, educationists and scientists. Considerable importance was attached to the ratings given by students and this study analysed how they rated ASEP units. The findings indicate that students tend to rate a unit as a whole, rather than giving objective ratings for each category. The authors believe that student opinions do matter; however, in a limited manner this study throws suspicion on the reliability of opinions obtained by questionnaires such as the ones used by the project. Types of studies needed are pointed out.

Power, C.N. *The effects of communication patterns on students sociometric status, attitudes and achievement in science.* (Ph.D. thesis) St. Lucia, University of Queensland, 1971.

Richardson, E. and Roy W. Stanhope. "Why do some secondary school pupils find science hard?" *The Australian Science Teachers Journal* 17(3):66-73, October 1971.

The study involved 1,700 pupils in Forms I-VI in five New South Wales schools which had a maximum variation of pupils within the Sidney area. Two open-ended questions were asked, "Do you find science easy or hard?" and "Give the reason for your answer." An analysis of all the responses resulted in the identification of 24 categories of 'hardness' (meaning, no doubt, *difficulty*) which in turn could be grouped under the cognitive domain or the affective domain. There were no responses in the psychomotor domain.

Rosier, Malcolm J. "A statistical picture of Australian science teachers_ some results from the IEA Science Projects," *Australian Science Teachers Journal* 19(4):27.29, December 1973.

Stanhope, Roy W. and E. Richardson. "Students' perception of factors contributing to the difficulty of secondary school science," *The Australian Journal of Education* 18(3):299-310, October 1974.

In the study 3,808 students indicated their degree of interest in science and its difficulty in comparison with other subjects. Then, through their responses to 33 structured items based upon the categories of difficulty, they assessed particular situations and whether in consequence science was 'hard', easy or about right. Positive relationships are reported between degree of interest in science and of its difficulty for all respondents and for various groups. Further analyses of response differences between boys and girls and between junior and senior pupils are presented.

Taplin, J.E. *An experimental study of human reasoning and conceptual behaviour.* (Ph.D. thesis) North Terrace, University of Adelaide, 1972.

Tisher, R.P. *A study of verbal interaction in science classes and its association with pupils' understanding in science.* St. Lucia, University of Queensland Press, 1970. 75 p. (Faculty of Education, University of Queensland papers, v. 1, no. 9)

This study is concerned with the teaching process and, in particular, with verbal interaction between teachers and pupils in classrooms and the effect that the teacher's behaviour has on pupils' development of understanding of science.

See also *Science education in nineteen countries, an empirical study* under the section "Asia" in this bibliography.

Hong Kong

Sanders, H. and R.T. Allsop. *Aspects of teaching and examining of chemistry at advanced level in Hong Kong.* Hong Kong, Research Unit, Department of Education, University of Hong Kong, 1974.

In 1973 a survey was undertaken of the teaching of form VI chemistry in 62 schools involving heads of science departments, science teachers and 200 students. Focus was on the role of practical work consisting of volumetric and observational exercises. Performances of the students were videotaped. Teachers considered a set of objectives for practical work and later considered to what extent the objectives could be achieved in a practical examination of the existing type. Among the several findings revealed by the study it appeared that, with the popularity of experimental work, there is a continuing need for teachers to be given access to new experimental ideas. Among several modes of assessment of practical work, the teacher-based assessment plus a compulsory question based on practical work in the written paper was preferred by the teachers.

Tao, P.K.I. *The development of an Attitude to Science Scale of the Integrated Science Project in Hong Kong.* (M.A. thesis) Leeds, University of Leeds, 1976.

India

India. National Council of Educational Research and Training. Department of Education in Science and Mathematics and Workshop Department. *School science education in India, study prepared for ACEID.* Bangkok, Unesco Regional Office for Education in Asia, 1977. 32 p. (ACEID. Studies of curriculum development centres in Asia 1)

Describes efforts of the Government of India for improvement of science education; in particular, through the National Council of Educational Research and Training (NCERT). The development of low-cost educational resources kits and mobile science laboratories, and activities stressing experimentation, enquiry and evaluation are reported.

Shekhawat, V. "Science education and scientific attitudes of Indian students," *Indian Educational Review* 7(2):1-10, July 1972.

The author postulates that the philosophy of science conflicts with the native Indian philosophy and therefore in spite of concerted efforts the majority of Indian youth remain alien to science. Another barrier to the learning of science is the foreign language employed. The author examines these issues and discusses the implications for methods and materials of science teaching to resolve the conflict.

Virk, H.S. "Teaching of science in Panjab schools, a critical survey," *School Science* 14(1):14-18, March 1976.

After the teaching of science was made compulsory in all the schools of Panjab, a survey was undertaken to assess the problems faced by students and teachers. The data reveal that the switches in language from Panjabi to English and vice-versa impeded progress in learning and teaching. The vernacular textbooks add to the confusion as different authors for books on the same subject used technical terms of their own; there is no standard glossary. Facilities for practical work are poor, and teachers are averse to using laboratories because of heavy workloads and bureaucratic bottlenecks in the purchase of science equipment. The data also reveal the discriminatory role played by English-medium model schools which tend to drive a wedge between the rural and urban areas.

See also *Science education in nineteen countries, an empirical study,* under the section "Asia" in this bibliography.

Iran

See *Science education in nineteen countries, an empirical study,* under the section "Asia" in this bibliography.

Japan

Basic study of the Integrated Science Curriculum.

This is a large-scale joint study started in 1971, co-ordinated by Professor Yoshinobu Kakiuchi of Tokyo University. The study is conducted by three groups. The first group. consisting of the staff of the Tokyo Metropolitan Institute for Educational Research and In-service Training, is attempting to develop an integrated science curriculum for the primary and lower secondary schools. The second group, consisting of the staff of Tokyo University and the National Institute of Educational Research, is attempting to clarify the learning process in terms of the inter-relationships between scientific interests and the development of scientific concepts. The third group, consisting of the staff of Gifu University, is attempting to clarify the learning process through the measurement and analysis of the teaching-learning process by the CMI system developed by the group.

Itakura, Kiyonobu. "The hypothesis-experiment-instruction method of learning, its implementation with two classwork books, 'Springs and force' and 'Magnets'," *Research Bulletin of the National Institute for Educational Research* (13):5-16, March 1975.

The method studied refers to a theory of science teaching which has as its goal the teaching of the basic, general concepts and principles of science and the provision of experiences through which students can learn about the nature and purpose of science. The classwork books to implement the method were given to 200 teachers who used them with more than 1,000 classes. The results of the experimental instruction with children from grades I-VIII showed that, when classbooks are given suitable problem content and ordering, teachers can provide effective instruction activities which students welcome enthusiastically and through which they learn thoroughly the concepts and principles that are objectives of the lesson.

See also *Science education in nineteen countries, an empirical study,* under the section "Asia" in this bibliography.

Korea, Republic of

Han, Bok-Soo and Jang-Ha Han. *An application of the KEDI Instructional Systems Model to science teaching in a middle school.* Seoul, Korean Educational Development Institute, 1974.

The results showed that the KEDI Instructional Systems Model was effective in improving student achievement; the upper and middle-level students in the experimental group achieved far more than their counterparts in the control group. The lower-level students in the experimental group showed no significant improvement in student achievement over those in the control group.

Malaysia

Asian Regional Institute for School Building Research. *The design of multi-purpose science laboratories for lower second-level schools in Asia*, by B.H. Soderberg. Colombo, 1970. 53 p. (ARISBR Study 11)

The size of many schools in the Asian region, especially in the rural areas, is such that were separate laboratories for physics, chemistry and biology to be provided, they would be grossly under-utilized. In such cases, one laboratory is usually sufficient for science teaching and learning in all three fields. For this study, cases considered are the design of an Integrated Science Laboratory in an area of its own for Malaysia, and a Multi-Science Laboratory for Sri Lanka where it is proposed to use a section of a typical open-hall school for science teaching at the lower secondary stage. The approaches in both case studies came about through analysis of needs resulting from a study of teaching methods, available equipment and schemes of work.

______. ______. 6 p. (ARISBR School Building Digest no. 9)

Relationships between cognitive development and the learning of science and mathematics. (Ph.D. thesis) Kuala Lumpur, Faculty of Education, University of Malaya /1972?/

Sulaiman, Siti Zaharah. *Mara Junior Science College: student selection and its implication for educational systems development in Malaysia.* (Ph.D. thesis) Ithaca, Cornell University, 1975. 377 p.

The research focused on the following questions:—1. How are students selected at Mara Junior Science College (MJSC)? —2. Does the selection process at MJSC contribute to Malay educational opportunity and social ability in the context of national educational development? The study revealed that the process of selection focuses on urban class values and on the paradoxical choice of getting a maximum number of qualified students, which screens out students with lower socio-economic background in the rural area. The study suggests a reorganization of MJSC as a residential school with a special focus and greater attempt to foster co-operation with outlying rural schools. Increased participation of students from lower socio-economic strata might be achieved by establishing a quota for MJSC admission of low SES and rural students.

Tan Yeao Leong. *Towards clearer understanding of the purposes of biology education in Malaysia.* (M.A. thesis) Keele, University of Keele, 1976.

Nepal

Nepal. Ministry of Education. Curriculum Development Centre. /*Survey of local resources in one district (Lalitpur)* Kathmandu, 1976?/

Through selected and concerned subject teachers of the district, a survey of local resources and educational materials was made. The study involved preparing, testing and modifying the educational resources, and providing a handbook to accompany them.

The New Educational Reform Associates. *Study of the supply and utilization of educational materials at the school level in Nepal.* /Kathmandu, 1975?/

Science education in the Asian region

This is a study carried out for UNICEF which provides suggestions and recommendations for the supply and utilization of educational materials.

New Zealand

McGrath, D.M. *The development of a test of science skills and processes.* (M.Ed. thesis) HU, 1973.

McMurray, B.C. *An evaluation of Form I science.* (Dip. Ed. study) PU, 1971.

New Zealand IEA National Centre. "IEA International standards of achievement" by R.W. Phillips, *Education* 25(6):10-11, 1976.

In the recent IEA surveys of achievement a large random sample of New Zealand students aged 14 and in form VII were placed among the leading countries in reading comprehension, literature, science and in the middle range for civic education and French. In science it was interesting to note that the biggest disparity in performance between boys and girls is in the understanding of abstract models and concepts of science. Girls appear equally capable of using higher cognitive abilities to solve problems or of simply recalling knowledge. The question remaining is whether girls fail in understanding through a need for more time to develop the concepts or through cultural elements in the material commonly used. There is also a strong hint in the evidence that *unguided* discovery methods produce inferior results. Discovery methods might aid the students' motivation, but *unless students are guided very skilfully* such methods may do very little to help the systematic accumulation of scientific knowledge and skills.

See also *Science education in nineteen countries, an empirical study,* under the section "Asia" in this bibliography.

Papua New Guinea

Gardner, Paul L. *Vocabulary difficulties of Papua New Guinean high school science students.* Victoria, Monash University, 1972.

English, which is a second language for most Papua New Guinea students, is the medium of instruction in secondary schools and may be a barrier in teaching and learning. A list of words which are non-technical but regarded as essential in the teaching of science was drawn up, tested, refined, and reduced to 650 words to meet the criteria. Other tests of picture recognition, synonym recognition, sentence completion and correct sentence usage were tried, and an acceptable test list constructed.

Jones, J. *Cognitive studies with students in Papua New Guinea.* University, Port Moresby, Educational Research Unit, University of Papua New Guinea, 1973. 50 p. (E.R.U. Report 10)

Students in Papua New Guinea experience considerable difficulty in dealing with much of the work to which they are subjected. This is true for all disciplines but is more clearly marked in the areas of science and mathematics. This investigation, in addition to revealing conceptual difficulties of students in secondary and tertiary institutions provides a fairly complete description of the group and individual testing programme, and suggests areas requiring further study. Based on the broad findings, a number of useful guidelines are given to facilitate the job of teaching and learning.

Mackay, Lindsay D. *An experimental evaluation of some aspects of secondary school science curriculum in Papua New Guinea.* Port Moresby, Department of Education, 1965-1972. 5 v.

Five studies were undertaken. —Study 1. In 1965 grade X science pupils were tested for readiness for further studies in physics, and compared with that of Australian children in grades VI-X. —Study 2. In 1967 the performance of grade X Papua New Guinea pupils and Australian grade X pupils were compared to identify the difference at the same grade level. —Study 3. In 1968 a test of understanding science was used in a longitudinal study over a year of students studying science in a teachers' college. This provided data on the effectiveness of the teachers' college science course in developing students' understanding of the nature of science. —Study 4. In 1970 the grade X population was tested with the 1967 Test of Readiness for further studies in physics; meanwhile the science syllabus had been modified. The performance was compared with the performance of the 1967 grade X population which enabled the assessment of the effects of innovation. —Study 5. In 1972, an analysis of common incorrect answers in multiple-choice questions in science examinations at grade IX and X levels revealed a pattern of behaviour termed "focusing," whereby pupils focused on only part of the information in arriving at an answer. Subsequently, a test of focusing was developed to examine this behaviour among secondary and tertiary students in Papua New Guinea.

Mackay, Lindsay D. "Understanding of the nature of science of some teachers' college students in the territory of Papua and New Guinea," *Papua and New Guinea Journal of Education* 6(5):72-85, June 1970.

The study was undertaken to determine: —1. The extent to which a science course in a teachers' college in Papua New Guinea was accompanied by changes in the understanding of science of students taking the course. —2. Some indication of the level of understanding of the nature of science of these trainee teachers at the beginning and end of their first year at a teachers' college. The results of the study indicate that the development of teachers' college courses which will bring about desired changes in the understanding of the nature of science of trainee teachers undergoing pre-service training must be given a high priority if future science teaching is to be meaningful.

Philippines

Almase, Araceli Gonzales. *Modification of teacher behavior through an in-service biology methods course.* (Ph.D. thesis) East Lansing, Michigan State University, 1973, published by the Science Education Center, University of the Philippines, 1975. 34 p. (UPSEC Monograph no. 7)

The study was designed to serve as a base for restructuring in-service and pre-service methods courses to include development of teacher behaviours which promote enquiry learning and for identifying factors which affect such behaviour changes. The study verified the hypotheses that teacher classroom behaviour can be modified along a predicted pattern supportive of enquiry learning through a methods course which provides experiences in analyzing teacher behaviour, enquiry and laboratory techniques and other skills essential to teaching of the BSCS materials.

Angeles, Amparo O. "An analysis on teacher questions and corresponding pupil responses in selected elementary science classes," *Studies in Science and Mathematics Education* (Science Education Center, University of the Philippines) (1):34-43, September 1973.

With the development of curriculum guides by the Bureau of Public Schools and the Science Education Center in the Philippines for elementary science which involve stimulating children to think, investigating and seeking answers to problems and evaluating facts by themselves, teachers find difficulty in making use of questions or formulating appropriate questions that call for thinking on the part of the child. This study analyses teachers' questions and corresponding pupil responses in selected primary science classes to determine types of questioning which could produce higher pupil achievement levels.

Ballada, Melquiades Q. "Improving mathematics skills through science concepts," *Studies in Science and Mathematics Education* (Science Education Center, University of the Philippines) (1):28-33, September 1973.

The title states a hypothesis that using certain activities in science to develop certain mathematics skills creates a purpose for learning these skills, and when there is purpose, learning is facilitated. Activities prepared for a unit were tested to see if they make learning mathematics and science interesting, useful and fun to the children.

Brush, Edwin Graham. *Science education in a Philippine village.* (Ph.D. thesis) Corvallis, Oregon State University, 1976. 329 p.

Research was undertaken to describe the teaching and learning of science with particular attention paid to cultural parameters. The local language was studied for its capacity to transmit scientific information. Logical operations were investigated to understand cultural influences on the development of cognitive skills. Selected village belief systems were studied in terms relevant to science education. Science education appears to have a role in the transition from a traditional to a modern cultural orientation; and the study indicates that science education must recognize and account for the importance of the local world-view.

Cabato, Ma. Sonia. "Adaptation of OSIA for grades five and six science classes," *Studies in Science and Mathematics Education* (Science Education Center, University of the Philippines) (1):44-53, September 1973.

The purpose of this study was to adapt OSIA (Observation System of Instructional Analysis, Hough, Duncan, 1970), an instrument to describe and evaluate what happens in a classroom, so as to produce a more accurate and quantitative description of interaction in science classes in the fifth and sixth grade levels at public primary schools in Quezon City, Philippines. The author recommends the use of the instrument in other primary science classes, schools and locations in the Philippines to help resolve basic problems connected with the implementation of a more process-centred approach in science and for improving the validity and reliability of the instrument.

Roxas, Segundo V. *Formative evaluation of the teacher's guide for a high school physics course developed by the Science Education Center of the University of the Philippines System.* (Ph.D. thesis) Boulder, University of Colorado, published by the Science Education Center, University of the Philippines, 1974. 27 p. (UPSEC Monograph No. 4)

The study sought to extract information regarding certain aspects of a Teachers Guide for a secondary school book developed by the Science Education Center, University of the Philippines entitled *Fundamentals of Physics*. The Guide was examined for clarity and adequacy of presentation of contents in terms of teacher needs, extent of usage by teachers, effectiveness of suggestions and absence of desired features. The thesis maintains that the Guide will serve a very useful function after specific recommended revisions and should enable teachers who have not attended in-service training institutes to teach the course satisfactorily. Secondary benefits derived from the study are methodological and cultural considerations from working with teachers.

Tiangco, Nenita-Fe Montano. *A study of the relationship among Philippine biology teachers' personality attributes, their understanding and knowledge of science, and student learning in science.* (Ph.D. thesis) New York University, 1973. 129 p.

Six instruments, one of which is Philippine-made - the Teacher Attitude Scale (TAS) - were administered in a city sample of Philippine biology classes. The instruments tested whether there is a relationship between teachers' personality attributes and teachers' understanding of and knowledge of science, and whether there exists a correlation between teachers' personality and students' understanding and knowledge of science.

Villavicencio, Rosalina R. *An analysis of the in-service training programmes for biology teachers in the Philippines with emphasis on their effectiveness in teaching inquiry-oriented materials.* (Ph.D. thesis) Austin, University of Texas, published by the Science Education Center, University of the Philippines, 1973. 18 p. (UPSEC monograph no. 3)

In the summer of 1972, a six-week biology summer institute was conducted in the five Regional Science Teaching Centers in the Philippines. Activities were planned to meet 11 objectives of the in-service training course which included lectures, discussions, field trips, and performance on the following: the rationale of the new materials and teaching strategies, formulation of instructional objectives and demonstration of teaching of science as enquiry. Two important changes observed after testing at the end of the training programmes were the increase in teachers' knowledge of biology concepts and the acquisition of the scientific skills and processes involved in enquiry teaching.

Zapata, Asuncion G. "An instrument for measuring the science interests of grade school children," *Studies in Science and Mathematics Education* (Science Education Center, University of the Philippines) (1):14-17, September 1973.

Thirty real objects categorized under plants, animals, matter, motion and force, energy and earth, and space, and 30 pictorial representations of the real objects were used for children to identify which were of interest to them. The experiment tested the consistency or reliability and validity of these instruments in determining the nature of science interests of a randomly selected group of students.

Sri Lanka

Asian Regional Institute for School Building Research. *The design of multi-purpose science laboratories for lower second-level schools in Asia,* by B.H. Soderberg. Colombo, 1970. 53 p. (ARISBR Study 11)

The size of many schools in the Asian region, especially in the rural areas, is such that were separate laboratories for physics, chemistry and biology to be provided, they would be grossly under-utilized. In such cases, one laboratory is usually sufficient for science teaching and learning in all three fields. For this study, cases considered are the design of an Integrated Science Laboratory in an area of its own for Malaysia, and a Multi-Science Laboratory for Sri Lanka where it is proposed to use a section of a typical open-hall school for science teaching at the lower secondary stage. The approaches in both case studies came about through analysis of needs resulting from a study of teaching methods, available equipment and schemes of work.

______. ______. 6 p. (ARISBR School Building Digest no. 9)

Ranaweera, A.M. *Integrated science in the junior secondary school in Sri Lanka, study prepared for the Asian Centre of Educational Innovation for Development.* Paris, Unesco Press, 1976. 31 p. (IBE and ACEID. Experiments and innovations in education 27. Asian ser.)

The present study gives comprehensive background information on science curriculum development from 1957 until the present day. Following the 1972 reforms, science became an important subject in the general education curriculum for grades VI to IX and took the form of integrated science.

Thailand

Boonyuen Chiraphongse. *A study of the charccteristics of elementary science teachers in Thailand and the competencies needed for improving their teaching.* (Ph.D. thesis) Manhattan, Kansas State University, 1975. 148 p.

The primary concern of this study was to gather data to support the planning of an in-service programme to improve science teaching. Analysis of the data obtained indicated that serious shortage of competent teachers was one among several factors causing student failure, and that the science programmes provided for children have not been practical or applicable to the daily lives of the children. From a science competency model which was developed, 45 out of 48 competencies were rated by science educators as the necessary standard for science teachers in the primary schools, and which teacher education programmes must develop.

Chancha Suvannathat and others. "Science achievement of Thai children in different grades," *Bangkok Institute for Child Study Research Bulletin* (16): 1974.

This is a study which was part of the project of the International Association for the Evaluation of Educational Achievement to study science achievement in 19 countries. The study involved 7,000 children ages 10 and 14 in grades X and XII. On the whole the children did poorly in the area of comprehension and application, but well on factual information. Science teachers for the lower grades were not specially trained in science courses. It was found that the achievement scores of Thai children were below the international grand means in all areas of science.

Chitra Noochmee. *A comparative study of the effectiveness of filmstrips produced abroad and in Thailand in science teaching in lower secondary schools.* (M.Ed. thesis) Bangkok, Faculty of Education, Chulalongkorn University [1972?] 121 p. (In Thai)

Mayuree Parakarn. *Evaluation of scientific equipment production project for teaching in M.S. 3 by the student teachers, College of Education, Prasarnmitr...* M.Ed. thesis) Bangkok, College of Education, 1974.

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The study surveyed the uses of scientific equipment by student teachers in third-year high school classes. The equipment used was made by the Scientific Equipment Production Project with the co-operative work of the teacher training programme. The study was concerned with the development of attitudes, interest, and appreciation of science, in addition to observation of skills in using scientific equipment and problem-solving by scientific methods. Some problems revealed by the study were lack of time and materials to produce science teaching/learning equipment.

Montian Wutikhun. *A comparison of mathematics and science achievement of students in municipal, private, Elementary Education Department schools, and schools of the Administrative Committee of Metropolitan Bangkok.* (M.Ed. thesis) Bangkok, Srinakharinwirot University, 1973. (In Thai)

Phatom-7 (grade-VII) students constituted the sample of the study. The instruments employed in the study were a mathematics test battery and a science test. Results of the study showed that for problem and reasoning tests, including science tests, the boys did better than the girls. For skills tests the girls did better. Analysis was also made by types of schools.

Paitool Suksringarm. *An experimental study comparing the effects of BSCS and traditional biology on achievement, understanding of science, critical thinking ability, and attitude towards science of the first year students at the Sakon Nakorn Teachers College, Thailand.* (Ph.D. thesis) University Park, Pennsylvania State University, 1976. 113 p.

The need for this experimental research originated from an increased interest in adapting the BSCS biology programme for use in Thailand, and in teaching biology as a means for the development of critical thinking ability and attitude toward science. The findings of this study may have implications for the teaching of science in teacher training institutions and programmes in Thailand, and they may decrease the cost of meaningful instruction.

Pornpimol Piyakesin. *The effectiveness of using pictorial riddles in teaching elementary school science in Thailand.* (Ed. D. thesis) Boulder, University of Colorado, 1976. 80 p.

A comparison of the effectiveness of the pictorial riddle approach to the traditional method of teaching elementary school science. More specifically the study attempted to determine: —1. Are pictorial riddles an effective approach for teaching science concepts to children? —2.What are the points of view of the teachers concerning the pictorial riddle approach? —3. What are the student's points of view concerning learning through the use of pictorial riddles. The pictorial riddle approach was found an effective method in teaching science concepts. Teachers observed that the method stimulated the students to a greater interest in learning science, and the students reacted very positively to the approach.

Smarn Vanchuplow. *A study of the education program of science teachers at Sri Nakharinwirot University, Bangsaen, 1963-1973.* (Ed.D. thesis) Los Angeles, University of Southern California, 1976.

The purpose of this study was to survey graduates' and faculty members' opinions about: (1) the curriculum and instruction of the education programme of science teachers, and (2) the college education which the graduates gained from the programme. The response to a questionnaire indicated competencies needed by science teachers and the type of programme and courses which should be offered. Selected recommendations called for regular evaluation of the curriculum with approximately one-half of the course work in the four-year programme devoted to courses in science and with inter-disciplinary courses introduced. Science instruction should be laboratory-oriented and emphasize the basic concepts and the application of science.

Sri-Nakharinvirot University. Behavioral Science Research Institute. *An experimental study of teaching science and mathematics to young Thai children.* Bangkok, 1976. 222 p. (Research report no. 14)

The objectives of the research were: —1. To study the behaviour of Thai children of different home backgrounds at the ages of 7-8 in response to teaching of certain science and mathematics concepts. —2. To determine the extent to which cognitive ability is related to achievement in schools. —3. To determine the effect of concept teaching on children in different locations. While the study showed relationships in science and mathematics concept scores and the school achievement scores in mathematics and science, the findings should be augmented with research implementations. The close association between two variables still depends on many factors such as educational policies. It is essential to develop a scientific attitude on the part of the learners, teachers and parents to make learning meaningful and beneficial.

Sriprapa Sonthikhan. *Report on the study of science and mathematics concepts of Thai children, a report submitted to the RECSAM International Committee for Research Co-ordination.* /Penang, SEAMEO-RECSAM?/ 1975.

The research tested the applicability of the Piagetian theory on intellectual development at the concrete operational stage when used with Thai children ranging in age from 7-12. The findings tended to agree with Piaget's statement that children form concepts in the cognitive area when they are between 7 and 12 years of age.

Tasanee Kunawatanawuti. *A comparative study of the effects of inquiry and traditional methods of teaching on the student's inquiry, cognitive styles and curiosity.* (M.Ed. thesis) Bangkok, College of Education, 1972. (In Thai)

The findings of the study showed that pupils who were taught by the active enquiry method and the combined enquiry method scored significantly higher than the traditionally taught students in the enquiry test and the analytical cognitive test. Analytical cognitive scores were found to be positively correlated with curiosity scores, but negatively correlated with relational cognitive scores. The enquiry scores tended to correlate curvilinearly with analytical cognitive scores and curiosity scores.

See also *Science education in nineteen countries, an empirical study* under the section "Asia" in this bibliography.

Publications in science education of Seameo-Recsam, Unicef, the Japanese National Commission for Unesco, and Unesco

(Titles have been compiled from publications in the Library of the Unesco Regional Office for Education in Asia)

SEAMEO/RECSAM

RECSAM Newsletter (Quarterly) Penang, Malaysia, SEAMEO Regional Centre for Education in Science and Mathematics 1967-

Projects, meetings and other activities are reported. Samples of teaching materials developed at the Centre are also included.

SEAMEO/DSE Regional Workshop, RECSAM, Penang, Malaysia, 3-12 October 1973. *Production of low-cost teaching materials for primary level science and mathematics, final report [of the Workshop] jointly sponsored by the Southeast Asian Ministers of Education Organisation and Deutsche Stiftung fur Internationale Entwicklung.* Penang, SEAMEO-RECSAM, 1973. 171 p. (DOK 712 A/a 11A-F25/73)

This meeting is a follow-up of an earlier meeting held in Singapore in 1972 on "Problems of Promotion and Production of Teaching Materials in Southeast Asia" organized by the SEAMEO Regional Centre for Educational Innovation and Technology (INNOTECH). The participants deemed it necessary that each country establish a national design and prototype production unit as a component of its curriculum development centre or a similar institution. It was also recommended that RECSAM include an equipment unit to ease the problem of shortage of trained personnel for design, production, evaluation and quality control of teaching/learning materials.

[SEAMEO-RECSAM] *Pilot project on concept learning in science and mathematics of Southeast Asian children, report on phase one.* Glugor, Penang, 1974. 1 v. (various paging)

This is a new instalment in a series of yearly reports on RECSAM's Pilot Project to find out how children learn science and mathematics concepts based on Piaget's theory of intellectual development. This report includes readings, revision of experiments, procedures and materials, a glossary and a report on partial findings of phase one of the project with an indication as to what may be done in the future.

SEAMEO-RECSAM. *Prototype curriculum materials for integrated science in Southeast Asian lower secondary schools.* Penang, 1973. 218 p. + Annexes.

A course for teaching science as a coherent whole through a unified approach for the three lower secondary levels. Prepared by RECSAM participants from eight Asian countries, the materials were geared toward prevailing conditions and needs. Among the 19 units prepared for the course, two units have been developed in detail consisting of a Teacher's guide, Pupil's guide, Pupil's worksheet and Evaluation items; with Indonesian, Khmer, Vietnamese, Thai and Laotian translations.

[SEAMEO-RECSAM] *SEASAME (Southeast Asia Science and Mathematics Experiment) introduction to systems, a prototype teaching unit to introduce Systems Thinking in science and mathematics at primary school level...* Penang, 1974. 72 p.

The purpose of the unit is to prepare pupils through science and mathematics activities to be better able to think in terms of relevant components which are related to the whole - and to one another, as well as their interactions and resultant changes: or in short to engage in "systems thinking". The early exposure of pupils to systems concepts is presumed to be crucial for a future rapidly changing, science-oriented society.

[SEAMEO/RECSAM Course Participants] RCB-1 and 2, Development of A Teaching Unit in Ecology and Population Biology, July-September 1974, Penang. *The pond ecosystem, a teaching unit for secondary schools.* Penang, SEAMEO-RECSAM, 1974. 1 v. (various paging)

This teaching unit on a pond ecosystem shows how ecology may be taught to pupils in a meaningful way as well as sustain their interest in the subject. It incorporates notes for the teacher, pupils' worksheets and working techniques. It shows how to record topography, how to identify and study abiotic and biotic factors, and how to select a suitable pond for study of ecology.

SEAMEO-RECSAM [Course Participants RCG-2, 15 January to 29 March 1973, Penang] *Prototype curriculum materials for integrated science in Southeast Asian lower secondary schools, presented to the SEAMEO Regional Centre for Education in Science and Mathematics.* Penang, SEAMEO-RECSAM, 1973. 1 v. (various paging)

The prototype materials include: 1. A three-year syllabus for the lower secondary science courses. -2. Specifications for 19 units. -3. A complete teacher's guide. -4. Students' worksheets. -5. Evaluation materials for units on Heat and Radiant energy (with translation in Indonesian, Khmer, Vietnamese, Thai and Laotian). -6. Suggested materials and equipment for all units.

[SEAMEO-RECSAM] Course Participants TC-Q1: Training in Development of Primary Science/Mathematics Apparatus, 29 September-10 December 1976, Penang. *A collection of primary science/Mathematics apparatus for the SEAMEO Region.* Penang, SEAMEO/RECSAM, 1976. 176 p.

Four kits in science and one in mathematics developed by the participants of the Workshop are described in this publication. In developing science apparatus, the following recommendations made by a SEAMEO Workshop were borne in mind. -1. Apparatus in the form of sets rather than separate items should be given priority. -2. Apparatus should be developed for teacher demonstration with possibilities for pupil activities. -3. Apparatus should be accompanied by a teacher's guide. Utmost consideration was also given to the availability of materials, expertise, facilities and production cost.

SEAMEO/RECSAM Course Participants TC-S2V: Modern methods in Teaching Science to Vocational Students. *Teacher's guide in science for vocational education.* Penang, SEAMEO-RECSAM, 1976. 106, xxv p.

Included here are a learning module and a series of lessons in the form of a teacher's guide. The topics covered are considered relevant to the experiences of vocational students and are based on the recommendations of the Regional Planning Workshop on the Teaching of Science and Mathematics to Vocational and Technical Students in Southeast Asia, 29 October-7 November 1975.

SEAMEO-RECSAM Participants and Consultants of Course RCC-1, October-December 1972. *A prototype teaching unit on electrochemistry of secondary school pupils in the SEAMEO countries.* Penang, SEAMEO-RECSAM, 1972. 172 p.

Cognizant of the fact that the teaching of chemistry varies from country to country in the organization of the syllabus, the kind of facilities available, in the number of years taught and other aspects; this teaching unit represents the level of understanding that should be expected of secondary students. The unit includes a student text, a teacher's guide, and laboratory worksheets which emphasize experimentation and scientific observation of the natural world rather than the memorization of facts. Through the experiments it is hoped that the students will know how scientists go about learning new ideas.

/SEAMEO/RECSAM Participants of/ Course TCE-1, October-December 1974. *Modern methods of teaching and evaluating science.* Penang, SEAMEO-RECSAM, 1974. 10 booklets.

A series of teaching units and teacher's guides developed through a training assignment. The topics covered are: Water-dissolving solids, Water-dissolving liquids, Sound, Pollution, Water, Heat, Crabs, Plants, Soil, Separating mixtures.

SEAMEO/RECSAM Participants RCG-2, 1975. *RECSAM Integrated science for secondary schools.* Penang, 1975. 3 v.

A series of units designed and developed for lower secondary school classes on the topics: Weather and environmental changes. -What are things made of? -Living together.

/SEAMEO-RECSAM/ Participants of RME-1 (April-June 1974) Course. *Development of primary science and mathematics apparatus, a collection of assignments, presented to SEAMEO-Regional Centre for Education in Science and Mathematics.* Penang, SEAMEO-RECSAM, 1974. 125 p.

The course commenced with acquainting the participants in the use of simple hand tools for wood, metal, glass and plastic working; in the properties of the spirit flame and the butane flame as tools for equipment production work; and in the safe handling of electricity in the classroom/laboratory. Producing equipment while training to handle tools familiarized the participants with various types of locally available materials and their properties. 'Brain-storming' sessions involved thinking out equipment ideas relevant to science and mathematics curriculum needs, listing equipment ideas on the constraints imposed by cost and local availability, and finding ways to meet as much as possible a desirability criteria for equipment.

/SEAMEO/RECSAM/ Participants TCB-1: Modern Curriculum Development and Evaluation in Biology, October-December 1973. *Selected teaching units on population biology/population education for secondary schools in SEAMEO countries.* Penang, SEAMEO-RECSAM, 1973. 1 v. (various paging)

With assistance of short-term consultants including a Unesco Mobile Team, the participants prepared eight teaching units on: 1. The role of population biology in secondary school science. -2. Integrating population education into secondary school biology. -3. Information on population density. -4. Population growth and environmental resistance. -5. Introduction to population biology for the second year. -6. Some classroom activities on population education. -7. Water pollution with respect to human population problems. -8. Food and population growth.

SEAMEO/RECSAM RCP-1 Course, October-December 1972. *Some ideas for curriculum reform in physics at the secondary level of schools within the South East Asian Region.* Penang, SEAMEO-RECSAM, 1972. 264 p.

In the course of producing a common prototype physics syllabus, the participants were introduced to the problems and methods of producing curriculum materials and of implementing curricula. While each participant worked individually on a project, each participant relied heavily on the criticisms and suggestions of his fellow participants to develop his work. The course also included a general survey of the place of physics within educational systems of the countries of the region and of the content of secondary physics programmes.

*SEAMEO-RECSAM Regional Planning Workshop on the Teaching of Science and Mathematics to Vocational and Technical Students in Southeast Asia, 29 October to 7 November 1975, Penang, Malaysia. *Final report.* Penang, SEAMEO-RECSAM, 1975. 144 p.

The Workshop identified problems in the learning of science/mathematics of vocational/technical students in Southeast Asia and made recommendations for RECSAM's training courses for teachers. An observation was made on the lack of scientists, engineers and technologists in developing countries and the need to make students understand and appreciate the supportive and applied roles of science and mathematics in the field of technology, as well as the need for teachers to help students apply practical ideas to improving the techniques and processes of production rather than becoming passive and routine workers.

UNICEF

UNICEF. *Illustrations of science teaching apparatus and equipment available from UNICEF... Supplement 1.* New York, UNICEF, 1973. 28 p. (In English, French and Spanish)

The apparatus and equipment are presented in drawings to enable non-specialists not conversant with their names to identify the teaching items when ordering or checking deliveries. Each drawing has a code number, and this number and the name of its corresponding apparatus are listed in a glossary.

UNICEF, New Delhi. *Preparation for understanding, helping children to discover order in the world around them,* text by Keith Warren, drawings by Julia Warren. New Delhi, 1975. 25 p.

The activities in this book avoid the use of too many words. The introduction to each activity is brief and is addressed to the children for the adult who is teaching, to speak just as it is written, or to modify to suit the children according to the materials available and the local situation. It is suggested that two or three children work together on the activities so that they can share and help each other, and learn co-operation. The book is intended to help children to understand science and to discover the patterns and arrangements of the world around them by using their hands, senses and minds.

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* This report was inadvertently omitted from the bibliography of reports of meetings and is therefore listed in this bibliography.

UNICEF, New Delhi. *Primary science apparatus from local resources.* New Delhi, 1975. 29 p.

This book has been prepared for use in primary schools in India. It shows teachers and pupils how to make apparatus and to use it in a simple way. Children will be able to make most of the items by looking at the photographs or hearing a teacher read the descriptions. Most of the things can be made quite quickly in a science lesson or at home.

Japanese National Commission for Unesco

Japan. Ministry of Education. *Guidebook for the teaching of science and mathematics in upper secondary schools in Japan.* Tokyo, Japanese National Commission for Unesco, 1974. 65 p. (MEJ 6858)

Chapter I gives background information on science and mathematics courses. Chapter II presents the objectives and course content for Integrated mathematics, Computer mathematics, Integrated physics, Integrated chemistry, Integrated biology and Integrated earth science. Chapter III discusses preparation of teaching programmes and points for consideration in handling and teaching the content of each course.

Japan. Ministry of Education. *Guidebook for the teaching of science in elementary schools in Japan.* Tokyo, Japanese National Commission for Unesco, 1972. 104 p. (MEJ 6811)

The objectives, content and relationship between science and other subjects made by the Curriculum Council for the teaching of primary school science are worked out in detail. Contents of science subjects for Grades I-VI are given in Chapter II. Points to consider when planning for teaching and activities to incorporate in lessons are discussed in the last chapter.

Japanese National Commission for Unesco, comp. *Training of science teachers in Japan: present and future.* Tokyo, 1970. 216 p. (MEJ 80027)

Through a collection of articles by scholars and specialists who are engaged in the training of science teachers, problems and views as to the present and future training of science teachers in Japan are reviewed.

Unesco

Baez, Albert W. *Innovation in science education — world-wide.* Paris, Unesco Press, 1976. 249 p.

The book is addressed to all those in a position to make an effective contribution to science education - decision makers, officials responsible for planning and/or supervising the science components of educational systems, members of teams working on the reform of science curricula, university and teacher training college staff responsible for the pre-service training of teachers, leaders of science teachers' associations, school directors and teachers directly concerned with innovative changes in science education. The book may also be of general interest to parents of school children and all those interested in contemporary educational issues. The book covers: The nature, goals and status of science education; -Recent efforts and what has been learned to improve science education including promising new trends in science education. -Possible strategies for improvement in science education.

Dyasi, Hubert M. "Integrated science education in African primary schools, technology and general education", *Prospects, Quarterly Review of Education* IV(1):63-71, Spring 1974.

This article highlights the technological component of science education projects of Ghana, Nigeria, Tanzania, Kenya, Lesotho, Liberia, Malawi, Mauritius, Sierra Leone, Somalia, Uganda and Zambia - members of the Science Education Programme for the primary level. The emphasis of a strong technological component involves doing away with the bookish approach to developing problem-solving skills and encouraging the practice of making rational choices.

Foecke, Harold A. "Science and technology education for development," *Prospects, a Quarterly Review of Education* II(2):221-228, Summer 1972.

This article is adapted for a paper presented at a Seminar on Policy and Executive Officers in 1971 in Nairobi, Kenya, on the theme of Education for Rural Development in Africa. The author believes that science education alone does not contribute much to education for problem-solving or education for decision-making; he recommends an integrated programme of science and technology education incorporating education for decision-making.

Stevens, R.A. *Out-of-school science activities for young people*. Paris, Unesco, 1969. 129 p.

A handbook covering a variety of activities prepared at Unesco's request by the chairman of the International Co-ordinating Committee for the Presentation of Science and the Development of Out-of-school Scientific Activities (ICC). These are chapters on clubs, science fairs, camps, meetings, museums and nature conservation.

Unesco. *New trends in integrated science teaching*. Paris, 1971, 1973, 1974, 1977. 4 v. (In English and French)

Volume I contains articles to define and illustrate integrated science. Volume II contains analysis, reviews and examples of integrated science teaching drawn from world-wide projects or teaching schemes ranging from the primary to university level. Volume III is on the education of teachers for integrated science based on the proceedings of a conference organized by the International Coucil of Science Unions (ICSU) Committee on the Teaching of Science with Unesco support and held at the University of Maryland (United States) in April 1973. Volume IV is on evaluation of integrated science education.

Unesco. *New trends in physics teaching*. Paris, Unesco, 1972, 1976. 2 v.

Volume I came out in 1968. Volume II, which was prepared in close collaboration with the Commission on Physics Education of the International Union of Pure and Applied Physics (IUPAP), is devoted to recent improvements in university introductory physics. Volume III is based on the proceedings of the International Conference on Physics Education held in Edinburgh (United Kingdom), 29 July-6 August 1975.

Unesco. *New trends in the utilization of educational technology for science education.* Paris, 1974. 247 p.

Current trends to improve teaching at all levels are explored. The topics covered are computer-based science education, programmed learning, television, radio, learning media, integrated multimedia systems, the professional training of science teachers and applications to developing countries.

Unesco. *New Unesco source book for science teaching.* Paris, 1973. 270 p. (In English and French)

A revised edition of the *Unesco source book for science teaching* which includes ideas and suggestions contributed by teachers all over the world for the use of common and widely available resources and materials for teaching science in primary and secondary schools. Ideas for devising simple scientific activities, investigations, and construction of equipment using local materials are also given. A section on laboratory safety is included. International and metric units are used.

Unesco. *Teaching school physics, a Unesco source book,* ed. by John L Lewis. Paris, Unesco; Middlesex, Penguin Books, 1972. 416 p.

The second in a series of Unesco source books designed to assist those involved in curriculum planning and development by providing information on new approaches and experiences using new methods and techniques in science teaching.

ABOUT THE BULLETIN

The Bulletin was published twice annually from 1966 to 1972 by the Unesco Regional Office for Education in Asia. As from 1973, it has been an annual publication. Each issue contains a bibliographical supplement. All issues prior to Vol. VII, No. 1 are out of stock, but may be consulted in libraries.

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